THE CITY OF CALGARY
Wastewater & Drainage
Urban Development

GUIDELINES FOR EROSION & SEDIMENT CONTROL

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PREFACE

Guidelines contained in this document are intended to assist with the implementation of erosion and sediment control measures by designers and administrators of the Stormwater Management System in Calgary. These are not intended as rigid procedures, as it is anticipated that those responsible for implementation will continue to utilize innovative approaches that best address specific situations.

Recommendations contained in this document were formulated on the basis of selected assumptions. It is important to note that the nature of existing and proposed development, modifications to watercourses, and inherent tolerances in calculation and design techniques, may have significant impact on the accuracy of outputs and not the preferred approach. Advances in technology will also continue to improve the methods and techniques that are currently employed in the design and construction of erosion and sediment control works. It is expected that the implementers will give due recognition to these factors during the decision-making process. For more information, see also City of Calgary "Stormwater Management & Design Manual" (2000) by Wastewater & Drainage.

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EXECUTIVE SUMMARY

This document has been adopted from various guidelines on Erosion and Sediment Control and the International Erosion Control Association (IECA).

During the construction phase of any urban development, eroded sediment during runoff events may increase by one thousand times or more compared to pre-development conditions. Many people are looking for controls that limit erosion runoff to a defined specific objective (i.e. x tonnes per hectare). However, the resources required to sample and measure erosion rates and to provide meaningful monitoring of the runoff controls, are not readily available at this time. Therefore, any erosion and sediment controls to be considered should be easy to design, implement and inspect.

As a result, guidelines were prepared that would enable a developer or municipality and/or their designates (consultants, contractors, etc.) to evaluate the potential for site erosion on the following basic information:

Slope gradient   Slope length   Soil type

Soil type is a good indication of soil drainage and erodibility. Knowing the soil classification and site topography, three broad classes of soil erodibility can be identified: high, medium and low. Soil erodibility is calculated on the exposed soil or sub-soil. It has been assumed that the natural vegetation on the site has been removed, and stockpiles and sub-soils are exposed and/or regraded.

Once the site has been classified as high, medium or low erodibility, and the slope gradient and length have been added, then the construction site can be assessed as low, moderate or high erosion potential. Knowing the potential of the exposed soil for erosion, appropriate erosion and sediment control measures, or best management practices (BMPs), can be determined.

Construction activities can result in a rapid increase in erosion and sedimentation, and if left uncontrolled, can irreparably harm the environment. Sedimentation of our rivers, streams and creeks can destroy fish habitat, and negatively impact water supplies, flood control, navigation, and recreational activities. The costs of cleaning up our environment afterwards can be high. As a result, regulatory requirements have been established to protect our receiving streams. Suitable erosion and sedimentation controls must be implemented to protect our environment and drainage systems.

All urban construction sites must consider minimum control measures to address the environmental pollution caused by: mud tracking onto municipal streets, windblown dust, and water borne sediments entering the municipal storm drainage system. Controls that accomplish the required objective enhance the desired outcome.

Throughout these guidelines, the approach has been to encourage prevention rather than to effect a cure; emphasis has been placed on protection of exposed surfaces and the control of runoff. Sediment control must be practised to prevent off-site damage due to sedimentation. Generally, this is achieved by filtering sediment-laden flow and impounding it to allow settling out of sediment particles. During construction periods on the site, the effectiveness of the controls in place must be visually verified, and proper maintenance must be carried out. Consultant inspectors are the first line of defense, and the success of the erosion and sediment control strategy will depend on their diligence. However, erosion and sediment control is everyone's responsibility, and everyone plays a part in the success of the overall plan. If the control measures chosen are not effective, then these methods or controls should be changed or modified. Otherwise, additional methods and controls must be added.

The erosion and sediment control process relies heavily on the developer/owner and consultant, and since no specific measurable objective has been defined, there will be a degree of judgement to be exercised. The methods and techniques outlined in Sections B and C of these guidelines consist of proven and commonly used control measures. Techniques used for unique situations have not been included. Modified methods and techniques will be required for unique site situations. In selecting the best method, the designer, contractor or site supervisor must consider feasibility, practicality and cost in relation to the environmental sensitivity of the receiving stream. It is anticipated that those responsible for implementation will utilize innovative approaches that best address specific situations.

Advances in technology will continue to improve the methods and techniques that are currently employed in the design and construction of erosion and sediment control works. While implementers should recognize evolving technology, erosion and sediment control plans should not be too complex, and some discretion in the choice of methods to meet goals must be given.

SECTION A

CRITERIA AND GUIDELINES

1.0 INTRODUCTION AND BACKGROUND

Stormwater runoff is part of the natural hydrological cycle. However, human activities, in particular urbanization, can have a profound impact on the quality of Calgary's rivers, streams and creeks. The hydrology of a site changes during construction (see Figure 1). Trees, meadows, grasses and agricultural crops that once intercepted and absorbed rainfall are removed and natural depressions that temporarily ponded runoff are graded over. The cleared sites increase imperviousness and stormwater runoff.

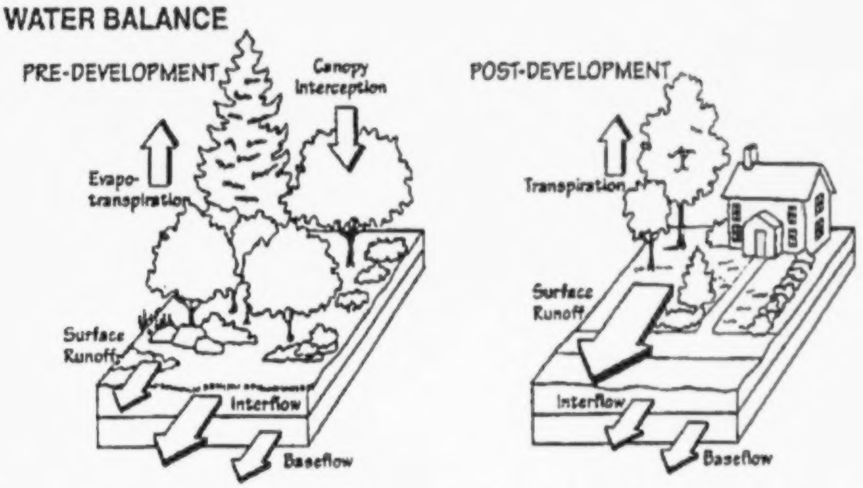


Figure 1: Water Balance at Undeveloped and Developed Sites (Schueler, 1987)

Construction activities can result in a rapid increase in erosion and sedimentation, and if left uncontrolled, can irreparably harm the environment, resulting in loss of valuable topsoil, and the subsequent sedimentation of rivers and other water bodies. Sedimentation of our rivers, streams and creeks can negatively affect water supplies, flood control, fish habitat and fishing, navigation and recreational activities. According to International Erosion Control Association (IECA), there is a wide range of erosion rate values that will vary depending on construction techniques, soil conditions, vegetation, and climate. However, on average, erosion rates for construction sites with no erosion control measures are 200-400 times higher than natural erosion rates for rural land use. The average erosion rate for urban construction sites is 20,000 tonnes/km^2/year.

It is important that our water resources are protected from erosion of the land or pollution caused by construction activities and other harmful activities. The costs associated with these damages can be significant. However, erosion and sediment control techniques can help protect these valuable resources by reducing the environmental impacts caused by sediment entering our receiving streams. The purpose of these guidelines is to provide developers, consultants, and contractors with practical methods for ensuring that urban construction is carried out in such a manner that a minimum amount of soil is eroded from the site and deposited in adjacent watercourses and/or drainage networks.

Erosion and sediment control techniques are part of Best Management Practices, or BMPs. BMPs are activities or practices, or a combination of practices, that are designed to prevent or reduce the release of pollutants to receiving waters or streams. BMPs operate by trapping stormwater runoff and detaining it until unwanted pollutants such as sediment, phosphorous and other harmful contaminants are allowed to settle out or be filtered through underlying soils. The trapped pollutants are then removed through regularly scheduled maintenance.

Care should be made in selecting the appropriate BMP or combination of BMPs. Overall, education is an integral component of successful design and implementation. It is the designer/consultant's responsibility to ensure that all BMPs are properly designed according to site conditions or constraints, and that details are provided on the drawings.

As government regulation and public awareness for increased protection for the natural environment grows, modern techniques for the natural resource protection become increasingly important. To protect these resources from erosion of the land or pollution caused by construction activities, it is essential to formulate and adopt criteria, policies and procedures for erosion and sediment control. Protection of downstream water uses will be a major factor in determining the degree of control to be implemented on the construction site and downstream from it.

The methods outlined in these guidelines can be used for large projects, such as a major subdivision, down to individual building sites. For small sites with low erosion potential that have minimal impact on the downstream water uses, the only controls that may be necessary are protecting storm sewers and dust control. For construction projects that are in or adjacent to watercourses or lakes, special consideration should be given to the method of construction. These situations should be reviewed prior to the initialization of the proposed Erosion Control Plan. Support documentation for alternative Erosion Control Plans must accompany the proposals.

2.0 REGULATORY REQUIREMENTS

Erosion from land surfaces can contribute large quantities of sediment to watercourses, which not only leads to the accumulation of sediment, but it can destroy fish habitat and other aquatic organisms, clog water intakes, increase dredging, and discharge contaminants. The erosion control process can result in significant benefits to the aquatic ecosystem.

There are a number of federal, provincial and municipal acts and/or legislation governing either urban development or sediment control in general. Failure to comply with this legislation can result in fines and/or imprisonment. **For further information, please refer to City of Calgary "Stormwater Management & Design Manual" (2000) by Wastewater & Drainage.**

2.1 FEDERAL

2.1.1 Navigable Waters Protection Act

The *Navigable Waters Protection Act* applies to in-stream work involving construction or placement in, on, over, under, through, or across any navigable water. "Navigable water" includes a canal and any other water created or altered as a result of the construction. Section 21 of the Act states:

"No person shall throw or deposit or cause, suffer or permit to be thrown or deposited any sawdust, edging, slabs, bark or like rubbish of any description whatever that is liable to interfere with navigation in any water, any part of which is navigable or that flows into any navigable water."

while Section 22 states:

"No person shall throw or deposit or cause, suffer or permit to be thrown or deposited any stone, gravel, earth, cinders, ashes or other material or rubbish that is liable to sink to the bottom in any water, any part of which is navigable or that flows into any navigable water, where there are not at least twenty fathoms of water at all times, but nothing in this section shall be construed so as to permit the throwing or depositing of any substance in any part of a navigable water where that throwing or depositing is prohibited by or under any other Act."

Contravention of sections 21 and 22 may be liable to a fine not exceeding five thousand dollars for each offence.

2.1.2 Fisheries Act

The *Fisheries Act* deals with the protection of fish habitat. The Act applies to work or improvements that cause the alteration, disruption, or destruction of fish habitat; this includes the impacts of urban development and sediment control. Section 35 of the *Fisheries Act* states that "no person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat." Section 36 of the Act regulates deposition of any substance (which would include sediment) which is deemed "deleterious" in waters frequented by fish. This act is regulated by the Department of Fisheries and Oceans.

2.2 PROVINCIAL

2.2.1 Environmental Protection and Enhancement Act

The purpose of the *Environmental Protection and Enhancement Act* is to support and promote the protection, enhancement and wise use of the environment. Part 4, section 98 of the Act states:

(1) No person shall ***knowingly*** release or permit the release into the environment of a substance in an amount, concentration or level or at a rate of release that causes or may cause a significant adverse effect.
(2) No person shall release or permit the release into the environment of a substance in an amount, concentration or level or at a rate of release that causes or may cause a significant adverse effect.

One of the definitions of substance is "any matter that is capable of becoming dispersed in the environment". This includes erosion resulting from construction activities.

Release of such substances is enforceable by Alberta Environment. Contravention of (1) may result in a fine of not more than $100,000 or to imprisonment for a period of not more than 2 years, or to both a fine and imprisonment, in the case of an individual. In the case of a corporation, this may result in a fine of not more than $1,000,000.

Contravention of (2) may result in a fine of not more than $50,000 in the case of an individual, or not more than $500,000 in the case of a corporation.

Remedial Measures

Under section 101 of the Act, there is also a duty to take remedial measures:

"Where a substance that has caused, is causing or may cause an adverse effect is released into the environment, the person responsible for the substance shall, as soon as that person becomes aware or ought to have become aware of the release,

    (a) take all reasonable measures to
        (i) repair, remedy and confine the effects of the substance, and

(ii) remove or otherwise dispose of the substance in such a manner as to effect maximum protection of human life, health and the environment,

and

(b) restore the environment to a condition satisfactory to the Director.

Contravention of section 101 may result in a fine of not more than $50,000 in the case of an individual, or not more than $500,000 in the case of a corporation.

2.2.2 Release Reporting Regulation (Alberta Regulation 117/93)

The *Release Reporting Regulation* is part of *the Environmental Protection and Enhancement Act (EPEA)* and deals with reporting requirements. Under section 99 of the EPEA, "a person who releases or causes or permits the release of a substance into the environment that has caused, is causing or may cause an adverse effect shall, as soon as that person knows or ought to know of the release, report it". Subsection 1 identifies the people that the incident should be reported to.

Pursuant to section 100 of the EPEA, a person who is required to report to the Director shall report in person or by telephone and shall include a report. Section 4 of the *Release Reporting Regulation* outlines the requirements for a written report. The Director may waive the requirement for a written report.

2.2.3 Wastewater and Storm Drainage Regulation (Alberta Regulation 119/93)

The *Wastewater and Storm Drainage Regulation* is also part of *the Environmental Protection and Enhancement Act* (EPEA). Section 7 deals with prohibited substances and releases. Section 7 of the Regulation states:

(1) No person responsible for a wastewater system or storm drainage system shall use or permit the use of a substance in or dispose of or permit the disposal of a substance into the wastewater system or storm drainage system in an amount, concentration or level or at a rate of release that may

(a) impair the integrity of the wastewater collection system,
(b) impair the integrity of the storm drainage system,
(c) impair the operation or performance of a storm drainage treatment facility,
(d) impair the operation or performance of a wastewater treatment plant, or
(e) impair the quality of storm drainage or treated wastewater and the gases and sludge produced in the treatment process,

unless the use or disposal is authorized by an approval.

(2) Subsection (1) does not apply to the use or disposal of a substance in or into a wastewater system or storm drainage system that results from or is for the purposes of controlling an emergency.

(3) Subsection (1) does not prohibit the use or disposal of substances intended for use in wastewater drainage collection systems.

Contravention of (1) may result in a fine of not more than $50,000 in the case of an individual, or not more than $500,000 in the case of a corporation.

2.2.4 Water Act

Lack of erosion and sediment control may also contravene the *Water Act*. Pursuant to Section 36 of the *Water Act*, an approval ***may*** be required for certain activities.

An activity is defined in the Water Act (Section 1, subsection (1)) as:

(i) placing, constructing, operating, maintaining, removing or disturbing works, maintaining, removing or disturbing ground, vegetation or other material, or carrying out any undertaking, including but not limited to groundwater exploration, in or on any land, water or water body, that

  (A) alters, may alter or may become capable of altering the flow or level of water, whether temporarily or permanently, including but not limited to water in a water body, by any means, including drainage,
  (B) changes, may change or may become capable of changing the location of water or the direction of flow of water, including water in a water body, by drainage or otherwise,
  (C) causes, may cause or may become capable of causing the siltation of water or the erosion of any bed or shore of a water body, or
  (D) causes, may cause or may become capable of causing an effect on the aquatic environment;

(ii) altering the flow, direction of flow or level of water or changing the location of water for the purposes of removing an ice jam, drainage, flood control, erosion control or channel realignment or for a similar purpose;

However, according to Schedule 1, section 2, an activity such as stripping or grading may be exempt if:

(d) landscaping that is not in a watercourse, lake or wetland if the landscaping does not result in
  (i) an adverse effect on the aquatic environment on any parcel of land, or

(ii) any change in the flow or volume of water on an adjacent parcel of land;

Alberta Environment should be consulted for more information.

2.3 MUNICIPAL

During the construction process, Drainage Authorization is required from Wastewater & Drainage (Inspection Supervisor) before any water may be disposed of through the City's storm sewer system. See City of Calgary "Standard Specifications Sewer Construction".

2.3.1 Drainage Bylaw 26M98

In 1998, the City of Calgary implemented the *Drainage Bylaw*. Pursuant to section 3, subsection 3, where an excavation of a parcel has been authorized by the issuance of a building, excavation or other municipal permit, water may be directed from the site into a storm catch basin within the storm drainage collection system but

(a) silt and debris shall be filtered to prevent them entry to the storm drainage collection system

Contravention of the drainage bylaw is punishable by a fine not exceeding $10,000 or imprisonment for a period not exceeding one year, or to both fine and imprisonment. An enforcement officer may, in addition to any other remedy at law, serve upon the person a violation ticket, allowing payment of the specified penalty. Recording of the payment shall constitute acceptance of a guilty plea and the imposition of a fine in the amount specified in Schedule B. Under Schedule B, first offence of 3(3) will result in a fine of $500; second and third offences are punishable with fines of $1000 and $2000 respectively.

Prior to pumping offsite, a permit is required. Contact Wastewater & Drainage or Urban Development for issuance of permits or for more information.

The City of Calgary is committed to providing water quality for stormwater runoff. Therefore, during development and construction of both large and small parcels of land, control of erosion and implementation of sedimentation practices is essential.

2.3.2 Streets Bylaw 20M88

The *Streets Bylaw* was implemented in 1988. Section 16 of the bylaw states:

"No person shall place, dispose, direct or allow to be placed, or disposed, any Material belonging to such person or over which that person exercises control of such Material, on any portion of a Street."

"Material" is defined as "any object or article, animal waste, ashes, building waste, dry refuse, garbage, industrial chemical waste, refuse and yard waste as defined in the Waste Bylaw, and includes sand, gravel, earth and building products."

Violation of this section may result in an Enforcement Officer issuing a warning directing the removal of the Material. Failure to head the warning may result in Work Forces performing the work at the expense of the person responsible.

As well, section 19 of the bylaw states:

"No person shall dispose of anything into a sewer, manhole, or catchbasin excepting those persons authorized by issuance of a permit by the City Engineer and at those sites authorized and designated as dumping stations by the City Engineer."

A person contravening any provision of this bylaw shall, upon summary conviction before a court of competent jurisdiction, be liable to a fine of not more than $2500 or in the event of non-payment of the fine, imprisonment for a period not exceeding 90 days unless such fine is sooner paid.

2.4 PERMITS

A **development permit** is required for all construction sites having a land use designation above R2 development. Within the existing development permit review process, site erosion control requirements will be reviewed and applied as conditions of the development permit.

Land is not permitted to be stripped or graded without a development permit or a Subdivision Development Agreement. This includes any form of land disturbing activities, and can include road grading.

Flow charts illustrating the stripping and grading process are included in **Appendix A**. Prior to the issuance of the stripping and rough grading permit, the conditions outlined in **Appendix B** must be agreed to between the Developer and the City of Calgary. A **Developer** is defined as any party undertaking stripping and grading or any form of land disturbing activity. This can include, but is not limited to, developers, landowners, contractors, consultants, and other City departments.

3.0 EROSION AND SEDIMENTATION PROCESS

Erosion

Soil erosion is the removal and loss of soil by the actions of wind, rainfall and runoff. In construction activities, soil erosion is caused by the force of falling and flowing water, resulting in the detachment and transport of soil particles. The force of raindrops falling on bare or sparsely vegetated soils is picked up and carried along with water running on the ground. Surface runoff (overland flow) occurs when the soil becomes saturated and its infiltration capacity is reduced. As the runoff gains velocity and increases in sediment concentration, overland flows entrain and transport particles first as a thin sheet of water moving over the ground. As the flow becomes more concentrated, more soil particles detach, resulting in minute channels or rills in the surface. Further increases in the velocity and volume of flow, increase the erosive power of the water within the rills which may gradually enlarge into gullies. Erosion is a temporary phenomenon that has the potential to carry significant amounts of sediment into watercourses or storm sewers during and immediately after rainstorm events.

The erosion process involves three basic stages:

Detachment - Transport - Deposition

Once sediment is detached from the land surface, the transport and deposition stages will determine how far the sediment is moved and where it will be deposited.

Sedimentation

Sedimentation is the settling out of soil particles transported by water. It occurs when the internal energy of the flow decreases to the point where particles can no longer be transported and settle out depending on their weight. Large particles, such as gravel and coarse sand, will be deposited first, followed by the fine sand, silt, and clay-sized fractions. This process commonly occurs when an increase in channel capacity or decrease in gradient causes a drop in the velocity of a stream. Sedimentation can occur in slower-moving, quiescent waterbodies, or in treatment facilities such as stormwater ponds.

Often clay particles will not settle out for extended periods of time due to their weight. As a result, settling by gravity is often ineffective and high turbidity can result. Turbidity can have detrimental effects on an aquatic environment. However, treating stormwater for turbidity can be an expensive and difficult process. Therefore, any prevention measures that reduce turbid water or the volume of turbid water that must be treated, are beneficial.

3.1 TYPES OF EROSION

There are generally four types of erosion that result from water:

Raindrop Erosion: The direct impact of falling drops of rain on soil, causes the dislodging of soil particles so they can be easily transported by surface runoff.

Sheet Erosion: This type of erosion is caused by the removal of a layer of exposed surface soil by the action of raindrop splash and runoff, as water moves in broad sheets over the land.

Rill and Gully Erosion: As runoff flows, it concentrates in rivulets, cutting grooves called rills into the soil surface. If water flow is sufficient, rills will develop into larger gullies.

Stream and Channel Erosion: Increased volume and velocity of runoff in an unprotected, confined channel may cause stream meander instability, scouring, and erosion of stream or channel banks and bottom.

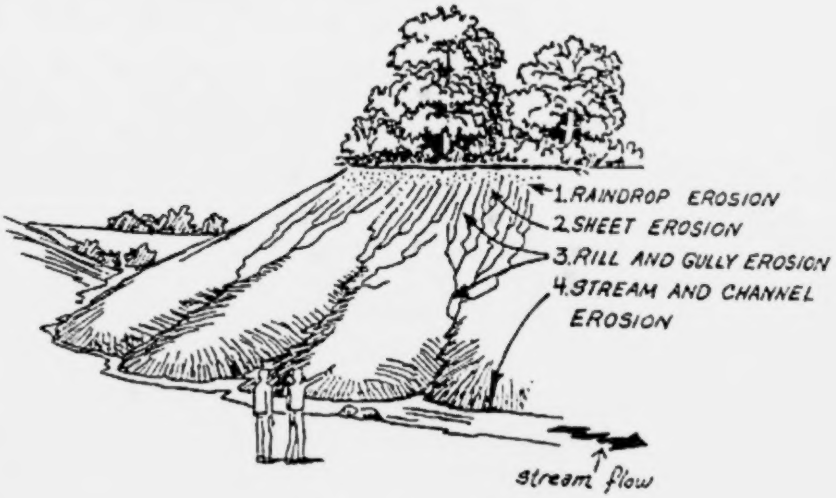


Figure 2: Types of Erosion

Soil erosion by wind creates a water quality problem when dust is blown into water. The lack of dust control during construction can be a significant problem. It can affect nearby sensitive habitat and wildlife areas, contribute to the accumulation of sediments and sediment transport in adjacent developed areas, and exacerbate dust and pollutant allergies in humans. Dust control is becoming a major consideration in erosion and sedimentation control.

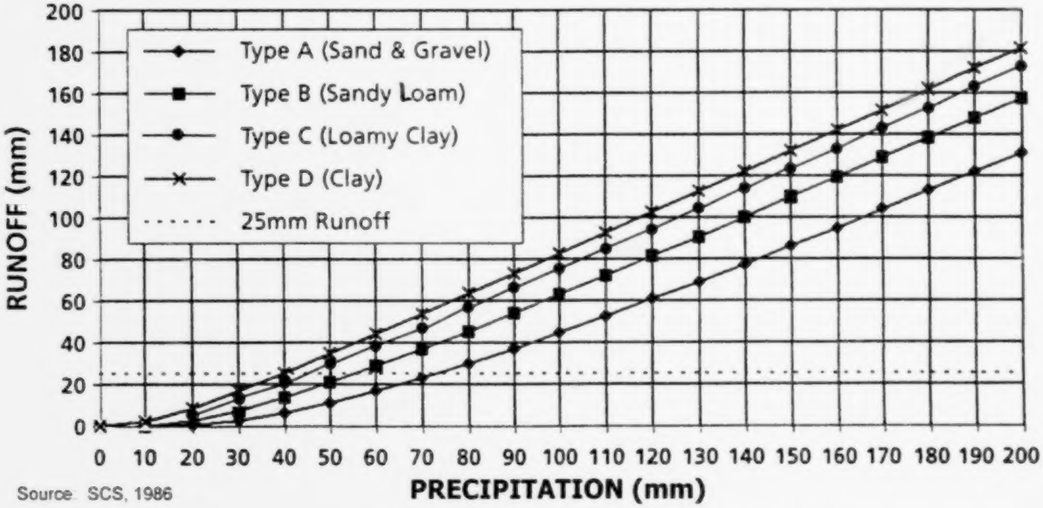
3.2 FACTORS INFLUENCING EROSION

The erosion potential of any site will depend on the soil characteristics, soil (vegetative) cover, topography, and climate.

Soil Characteristics

Erosion is influenced by soil properties such as particle size, organic content, soil structure and soil permeability. These factors affect the infiltration capacity of a soil and the resistance of the soil to erodibility. Soils containing high proportions of silt and very fine sand are usually the most erodible. Erodibility is decreased as the percentage of clay or organic matter increases. However, once eroded, clays are easily transported.

Organic matter, particle size and gradation affect the soil structure by the arrangement, orientation and organization of particles. In general, well-drained and well-graded gravels and gravel mixtures with little or no silt are the least erodible soils. See Figure 3.



Source: SCS, 1986

Figure 3: Soil Type and Runoff Comparison

Soil (Vegetative) Cover

Vegetative cover helps control erosion by shielding the soil surface from rainfall, slowing the velocity of runoff, maintaining the soil's absorption capacity, and holding soil particles in place. Soil erosion can be reduced by limiting the removal of existing vegetation and decreasing exposure time of denuded areas.

Topography

The amount and rate of stormwater runoff is affected by the size, shape and relative elevation differences of the watershed or construction area. These unique characteristics can provide both opportunities and limitations for the use of specific control measures. Slope length, steepness, and orientation are all factors that should be considered.

Climate

Climate, and its associated weather, rainfall and rainstorm events, is somewhat predictable by seasonal and historic records. While the timing of a rainfall event is not predictable, the risks can be minimized by appropriate planning and using properly designed management practices and techniques. During the winter, chinooks can create potential erosion concerns due to lack of snow cover and an increase in wind erosion.

Consideration should be given to these factors where possible. While climate is an uncontrollable variable, seasonal variations tend to be regional and can generally be accommodated through construction scheduling. Where possible, existing soil (vegetative) cover should be maintained. However, for the purposes of site specific evaluation of construction sites, the worst case situation should be considered for soil cover (i.e. where no protective cover is left in place).

Topographic evaluations may be based on consideration of slope length and slope gradient, while soil characteristics may be summarized through a description of soil texture and soil drainage. The guidelines that follow will utilize these four factors to characterize a site as low, moderate, or high erosion potential.

A qualitative evaluation of construction site erosion potential will provide the developer and reviewing agencies with the basic information required for the selection and evaluation of appropriate erosion and sediment control measures.

4.0 PLANNING

4.1 GOALS & OBJECTIVES

The main objective of erosion and sediment control is to protect our watercourses from pollution, primarily sediment pollution. Most sediment concerns have arisen due to urbanization of rural areas through the construction process. Development has increased the availability of sediment material and contaminants. The objective of sediment and erosion control is to prevent pollution by limiting the amount and rate of erosion occurring on disturbed sites and by capturing eroded soil before it leaves the construction site. The best strategy for managing sediment and erosion control is to direct efforts towards prevention of problems. One of the most effective ways to prevent sediment from entering and degrading watercourses is to control it at the source. Planning, design and construction can help reduce or avoid the impacts of erosion and sedimentation. However, such controls must be planned in advance and implemented during the development phase. This requires a new attitude towards carrying out construction activities. It is also important that **everyone** participate and contribute towards successful implementation to protect our watercourses. This includes the City of Calgary, developers/landowners, consultants, contractors, road builders, home builders, and homeowners.

Equally important for effective sediment and erosion control is the need for regular inspection and maintenance, and to make repairs as required. The construction phase of a project or development is usually considered a temporary condition, which will normally be replaced by permanent structures and facilities. However, the construction work may take place over an extended period of time. Any management practices and control facilities should be of sufficient size, strength and durability to outlast the expected construction schedule. The main objective of pollution prevention is to anticipate and avoid stormwater-generated situations that delay construction, add costs to the project, result in blame, and cause immediate and long-term environmental loss and degradation.

4.2 RESPONSIBILITIES

Erosion and sediment control is ultimately the responsibility of the property owner, which is typically the developer or landowner. However, the landowner can also include the City of Calgary. Although the developer/landowner has prime responsibility,

Erosion and Sediment Control is Everyone's Responsibility!

Everyone has a role in protecting our watercourses through erosion and sediment control. This includes:

- Federal Government
- Provincial Government (Alberta Environment)
- City of Calgary
- Developers/Land Owners
- Consultants
- Contractors
- Road Builders
- Home Builders
- Landscapers
- Homeowners

Training and public education are essential to making erosion and sediment controls work. The City of Calgary will endeavour to provide training to the appropriate parties on a regular basis and to conduct a public education program for homeowners and builders.

4.3 EFFECTIVE PLANS

Why Erosion & Sediment Control Plans Fail

A survey of Erosion & Sediment Control (ESC) programs conducted by Brown and Caraco (1996) in the United States discovered that 10% of ESC programs appear to exist only on paper. Insufficient staffing prevented adequate plan review or inspection.

It is important to understand the reasons why ESC plans fail. Firstly, many ESC plans are not well integrated with other stream protection efforts occurring during construction. Construction is potentially the most destructive stage in the development with the removal of topsoil and trees, soil exposure, steep slope cutting, alteration of natural topography and drainage, wetland filling and riparian areas disturbed. An ESC Plan is more than preventing sediment from leaving the site; it should clearly outline where and how BMPs for stream protection, wetland protection and forest conservation should be employed. It is important that stream protection measures be clearly marked on the plan. It is also important to know the sensitivity of the site and receiving stream.

All too often, ESC programs are developed in isolation from other stream protection plans prepared for the site; someone designs stormwater management practices, someone else does the grading plan, and others assemble wetland protection or other sensitive area requirements. Full integration and understanding is needed.

Although the responsibility for developing a quality ESC Plan usually falls to the design engineer, it is often delegated to junior engineers who possess little ESC training or experience. Given the limited resources, it is not surprising that ESC Plans are of poor quality or are lacking in detail.

Elements of an Effective ESC Plan

Implementation of ESC plans can be improved. The ten elements outlined in Table 1 present a comprehensive and integrated approach for achieving stream protection during construction. Only four of the elements actually involve better design and selection of ESC practices. Three of the elements emphasize non-structural techniques for erosion prevention, while the last three elements involve management techniques.

Table 1: Ten Elements of an Effective Erosion & Sediment Control Plan

	TEN ELEMENTS OF AN EFFECTIVE EROSION & SEDIMENT CONTROL PLAN
1.	***Minimize Needless Clearing and Grading***
2.	***Protect Waterways and Stabilize Drainage Ways***
3.	***Phase Construction to Limit Soil Exposure***
4.	***Stabilize Exposed Soils Immediately***
5.	***Protect Steep Slopes and Cuts***
6.	***Install Perimeter Controls to Filter Sediments***
7.	***Employ Advanced Sediment Settling Controls***
8.	***Ensure Contractors are Trained on ESC Plan Implementation, Inspection, Maintenance and Repairs***
9.	***Adjust ESC Plan at Construction Site***
10.	***Assess ESC Practices After Storms***

1. **Minimize Needless Clearing and Grading.** Some areas of a development site should never be cleared and graded, or these activities restricted. This includes stream buffers, forest conservation areas, wetlands, springs, highly erodible soils, steep slopes, and environmental areas.

2. **Protect Waterways and Stabilize Drainage Ways.** Streams and waterways are particularly susceptible to sedimentation. Clearing adjacent to a waterway should not be permitted, and a silt fence should be installed along the perimeter of the buffer. Existing drainage ways should be identified, as these will likely be the major routes that eroded sediments will take to reach streams, rivers and storm sewers. Drainage ways are also prone to erosion due to the high velocity of runoff. Erosion should be minimized.

3. **Phase Construction to Limit Soil Exposure.** Large areas of grading should be avoided since this maximizes erosion potential. Construction phasing, where only a portion of the site is disturbed at one time, minimizes sediment load potential.

4. **Stabilize Exposed Soils Immediately.** To provide soil stabilization, it is important to establish cover over the denuded area within a short period of time of the soils being exposed. Covers such as grass, mulch, erosion control blankets, hydroseeding, and plastic sheeting can be used to achieve this.

5. **Protect Steep Slopes and Cuts.** Steep slopes are the most highly erodible surfaces within construction sites. Steep slopes are generally defined with slopes of 6H:1V to 3H:1V or greater. Where possible, clearing and grading of steep slopes should be avoided. Otherwise, special techniques, such as uphill flow diversion and silt fencing, should be used to prevent uphill runoff from flowing down the slopes.

6. **Install Perimeter Controls to Filter Sediments.** Perimeter controls should be implemented at the edge of the construction site to retain or filter runoff before it leaves the site. Silt fences and earth dikes or diversion are the two most common controls.

7. **Employ Advanced Sediment Settling Controls.** Even when the best ESC measures are employed, high concentrations of sediments may be discharged during larger storms. Therefore, the ESC plan should include some sediment traps or basins to allow captured sediments to settle out. To improve the trapping efficiency, these basins must be designed to incorporate features such as larger volumes, use of baffles, skimmers and other outlet devices, and multi-cell construction. Regular inspection and maintenance are also critical to the operation of these practices.

8. **Ensure Contractors are Trained on ESC Plan Implementation, Inspection, Maintenance and Repairs.** The most important element in the implementation of an ESC plan is the training and experience of the contractors, as they are usually responsible for installation and maintenance of the practices. In the end, everyone is responsible for erosion and sediment control. Therefore, training and education is important for everyone, from the developer down to the homebuilder. Everyone is working towards the same goal of protecting our waterways.

9. **Adjust ESC Plan at Construction Site.** For an ESC plan to be effective, it may have to be modified due to discrepancies between planned and as-built grades, weather conditions, altered drainage and unforeseen requirements. Regular inspections are needed to ensure that ESC controls are working

properly. Inspections should be conducted every seven days and following heavy rainstorms or snowmelt events.

10. **Assess ESC Practices After Storms.** After a rainstorm, it is usually clear whether an ESC plan worked or not. If the storm was unusually large or intense, it is likely that many of the controls will require repair, clean out, or reinforcement. Therefore a quick response to assess and correct damages of the controls is required.

4.4 SITE EROSION POTENTIAL

The need for protection of the downstream water uses will determine what control measures will be required. If the downstream environment is very sensitive to increased turbidity, then on-site controls will have to be considered to give the necessary protection. Where it is feasible and practical to provide on-site depression with no outlet, such that all sediment-laden stormwater can drain to it, then no erosion controls will be necessary. However, the question of safety, due to permanently ponded water will have to be addressed. **Ideally, if the erosion process of detachment, transport and deposition occurs entirely on the construction site, then erosion controls could be unnecessary.** Where storm flows leave the site along either temporary or permanent routes during construction activities, then both erosion and sedimentation controls will be needed to some degree.

Site erosion potential is a measure of the erodibility of the site sub-soil, where consideration is given to:

- site surface slope gradients;
- length of site slopes;
- soil erodibility (based on soil drainage and soil texture).

When soil particles are picked up by stormwater flowing over the surface, the size of the soil particles, and the quantity transported downslope, will increase with the increase in velocity of the runoff. When moving downslope, a change in the slope to a flatter gradient will result in a decreased velocity and a decreased transport capacity. At that location, sediment will be deposited, starting with the larger size, followed by smaller particles. In general, long and/or steep slopes are more prone to erosion than short and/or gentle slopes. As stated earlier, the concern is that material could leave the site, as opposed to the soil being moved by runoff from one part of the site to another. Transported soil can leave the site overland or through the storm sewer system.

The evaluation of a construction site will require large-scale topographic mapping. This will be available, in most cases, as part of the information required by the developer prior to the submission of a draft plan, or by the municipality prior to detailed design of any construction work. If this is not available, then existing topographic mapping may be used, at a scale not smaller than 1:2000 with 1m contour intervals. It is recommended that the topographic mapping be extended 50 m beyond the boundary of the construction site to ensure that the surrounding topography is taken into account when selecting site erosion and sediment control measures.

4.4.1 Slope Gradient

On steep slopes, the downslope component of gravity is increased and the component normal to the surface is decreased. This means that not only is less force per unit area required to entrain particles, but the amount of overland flow is increased. As a result, susceptibility to erosion increases sharply with slope angle.

Gradients should be measured perpendicularly to the contours and computed as a percentage. The slope percentage is the vertical distance divided by the horizontal distance (i.e. a 1:1 slope equals 100% slope). Three slope classes are defined in Table 2 for use in the site evaluation.

Table 2: Slope Gradient Classes

Slope* (%)	Description
0 – 10	Gentle
10 – 15	Moderate
Over 15	Steep

* Vertical distance: horizontal distance between two contours computed as a percentage

Slope zones should be delineated on the topographic contour map(s) so that all regions within the construction site are labeled according to one of the above slope classes.

Determining the boundaries for both regions of uniform and sharply discontinuous relief is relatively straightforward. However, delineation of areas with varying slopes may not be as simple. In some cases it may be necessary to measure the gradient between individual contours (i.e. 1 m) to ensure adequate consideration of small scale topographic variations. Despite slight interpretative variation in certain cases, a good general picture of slope gradients throughout the construction site can be obtained in this manner.

Normally the slope gradient analysis is carried out on the original site contours, after stripping topsoil and before any regrading or installation of site services (i.e.

the worst case). If major earth moving takes place to achieve the final site grading, the slope zones considered should be average slopes, taking into account the original and final grades. The number of zones per site should be as few as possible, with emphasis placed on the perimeter of large sites.

4.4.2 Slope Length

The velocity and volume of overland flow tends to increase with slope length and hence, susceptibility to erosion. Slope lengths should be determined for each of the slope zones identified in the previous section by measuring the distance from crest to toe, perpendicularly to the contours (the total length of the slope should always be used even if it lies partially outside the construction site boundary). These guidelines employ a two-class slope length assessment as defined in Table 3.

Table 3: Slope Length Classes

Length* (%)	Description
Under 70 m	Moderate
Over 70 m	Long

* Slope length measured down the slope face

Each of the three gradient classes can now be assigned one of two length classes, moderate or long, making a total of six topographic classes.

4.4.3 Soil Erodibility

The soil characteristics of texture and drainage may be used to obtain an estimate of soil erodibility (K). Soil erodibility is the ability of the soil to resist entrainment and transport by rain splash and overland flow.

For each of the slope zones identified in **Section 4.4.1**, a determination of soil erodibility is required.

In most cases a construction site evaluation will require subsurface soil data, since usual construction practice involves the stripping of topsoil. This data should normally be available as part of the geotechnical survey undertaken by the developer prior to the submission of a draft plan, or by the municipality prior to detailed design of any construction work.

Soil Texture

Soil texture refers to the particle sizes of the individual soil grains composing the soil. The relative proportions of sand, silt and clay can be determined through laboratory analysis or field estimation, and used to classify the soil as being coarse-textured (sandy), medium-textured (loamy), or fine-textured (clayey). The organic content need not be considered since, in most cases, organic material will be removed during the topsoil stripping of a construction site. Coarse particles are not readily entrained because of their frictional resistance and high infiltration capacity, while clay-sized particles have high-cohesive strength. As a result, sandy and clay soils tend to exhibit low erodibility, while loamy soils range from medium to high erodibility.

Table 4 can be used to obtain the textural class and associated erodibility of a given soil. The erodibility classification is a simplified one. This three-class approach provides a good general indication of soil erodibility. In most cases this textural description will incorporate soil drainage characteristics, since permeability (in general) varies directly with grain size.

Although Table 4 includes most of the soil types, additional information on detailed soil types within an area may warrant modification of the soil erodibility classification. For example, while sand is classified as having low soil erodibility, fine sand (not classified) may exhibit medium soil erodibility. The moisture content of a soil prior to a rainfall event will have a significant influence upon its erodibility. This is readily apparent in the case of poorly drained soils, since the degree of saturation in conjunction with precipitation intensity will determine the infiltration capacity, and therefore the amount of erosive overland flow. As a result, the erodibility classifications given in Table 4 should be "bumped up" one class in situations where the initial soil moisture content of the site is likely to be high (i.e. after snowmelt).

Soil Drainage

The infiltration capacity of a soil reflects its ability to drain moisture via the force of gravity. Reduced infiltration results in surface ponding and overland flow which leads to increased surface erosion.

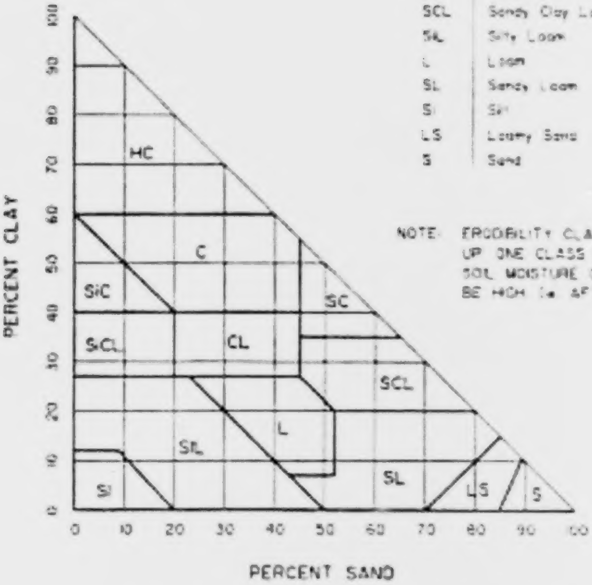
One of the most significant factors affecting soil drainage is soil structure (the arrangement of soil particles), which affects the permeability of the soil (its ability to transmit water through pore spaces). Soil structure can be adversely affected by heavy machinery, which compacts the surface soil and reduces infiltration.

Topography and depth of the parent material will also influence the drainage characteristics of a soil since poorly drained soils are frequently found in regions of concave relief, or areas where a thin layer of soil overlies impermeable material.

Table 4: Soil Erodibility

KEY	SOIL TYPE	SOIL ERODIBILITY (K)
HC	Heavy Clay	Low
C	Clay	Low
SiC	Silt Clay	Medium
SC	Sandy Clay	Low
SiCL	Silty Clay Loam	Medium
CL	Clay Loam	Medium
SCL	Sandy Clay Loam	Medium
SiL	Silty Loam	High
L	Loam	High
SL	Sandy Loam	Medium
Si	Silt	High
LS	Loamy Sand	Low
S	Sand	Low

NOTE: ERODIBILITY CLASSIFICATIONS (K) SHOULD BE 'BUMPED' UP ONE CLASS IN SITUATIONS WHERE THE INITIAL SOIL MOISTURE CONTENT OF THE SITE IS LIKELY TO BE HIGH (i.e. AFTER SNOW MELT)


PERCENT CLAY
0
10
20
30
40
50
60
70
80
90
100
HC
C
SiC
SC
SiCL
CL
SCL
SiL
L
SL
Si
LS
S
0
10
20
30
40
50
60
70
80
90
100
PERCENT SAND

SOIL TEXTURE CLASSES. PERCENTAGES OF CLAY AND SAND IN THE MAIN TEXTURAL CLASSES OF SOIL. THE REMAINDER OF EACH CLASS IS SILT

SOIL TEXTURE NOMOGRAPH

4.4.4 Evaluation of Site Erosion Potential

Having labeled all regions within a construction site according to slope gradient and length, this topographic information can be combined with the soil characteristics of texture and drainage to yield the various zones of site erosion potential. The procedure is outlined in Table 5. (Note that for steep slopes both length classes are considered equivalent.)

Table 5: Erosion Potential

Topographic Classes		Soil Erodibility[3]			Erosion Potential
Gradient[1]	**Length[2]**	**Low**	**Medium**	**High**	
Gentle	Moderate	Low	Low	Moderate	
	Long	Low	Moderate	High	
Moderate	Moderate	Low	Moderate	High	
	Long	Moderate	High	High	
Steep	Moderate	Moderate	High	High	
	Long	Moderate	High	High	

NOTES:

1. Slope Gradient Class is determined from Table 2
2. Slope Length Class is determined from Table 3
3. Slope Erodibility Class is determined from Table 4

All zones within the construction site should be assessed as being low, moderate or high erosion potential.

4.5 PROTECTION OF DOWNSTREAM WATER USES

The protection of downstream water uses is a consideration for the degree of erosion and sedimentation controls required for the site. The nature of the land between the construction site and the receiving watercourse, or waterbody, will have a bearing on the downstream impacts.

Where sediment-laden flow would travel overland from the construction site onto public or private property that could not tolerate sediment deposition, then considerable protection will be required. Otherwise, overland flows may cross private property, enter the watercourse, and end up in a waterbody.

Once the severity of the impacts on water uses has been determined, then the need for on-site erosion and sedimentation controls can be assessed.

4.6 EVALUATION SUMMARY

With both the site potential for erosion and the protection of downstream use integrated, then a determination can be made of the erosion and sediment control measures to be implemented on site and downstream.

The evaluation should take into account that after the topsoil has been stripped from a site, the erosion process could start. Where the site has to be regraded to final elevations, the direction of sediment-laden flow could change. Overland flow routes, for both initial and final site grade conditions, should be checked to ensure that the appropriate downstream environment sensitivity has been evaluated.

The route to a receiving watercourse can be overland or through the storm sewer system. Both routes should be evaluated before and after the final overland flow route(s) is constructed and/or available.

Minimum erosion and sediment control measures will be needed in all instances. These are also referred to as "good housekeeping" measures. If there are impacts on downstream uses, and/or the erosion potential increases, then additional measures will need to be implemented.

Table 6 outlines the relationship of site erosion potential, the impacts on downstream water uses and the degree of erosion and sediment controls that should be considered.

Table 6: Degree of Erosion and Sediment Control

Site Erosion Potential	Impact on Downstream Water Uses	Degree of Erosion and Sediment Control
Low	Negligible	Good housekeeping measures only
	Yes	Consider sedimentation pond(s)
Moderate	Negligible	Erosion and sediment controls
	Yes	Erosion controls and sedimentation ponds(s)
High	Negligible	Erosion and sediment controls
	Yes	All flows to on-site sedimentation pond(s)

Selection of the appropriate erosion and sediment control measures for the construction site requires that, in addition to the zones of erosion potential, the initial and ultimate drainage network be highlighted, the inlets and outlets to piped sewer systems be identified and spoil pile locations be identified.

The information is to be included in the Erosion and Sediment Control Report. Refer to **Section 7.0 Technical Requirements** for details.

4.7 DESIGN APPROACH

An Erosion and Sediment Control Plan should be prepared for **all** construction projects. For Drainage & Site Servicing Plan (DSSP) sites smaller than 2 ha (5 acres), this will consist of minimum control measures known as good housekeeping practices. Good housekeeping measures should be indicated on the construction drawings. DSSP sites larger than 2 ha require the submission of an Erosion and Sediment Control Report. See **Section 7.0 Technical Requirements**. Sites smaller than 2 ha may be required to submit an Erosion and Sediment Control Report if the site is close to a receiving stream or is otherwise deemed to be in or adjacent to a sensitive area (i.e. ER, ravine, etc.).

Development of an effective ESC plan is important to protecting our watercourses from sediment pollution. When developing and implementing an ESC plan, the steps outlined in Figure 4 should be followed.

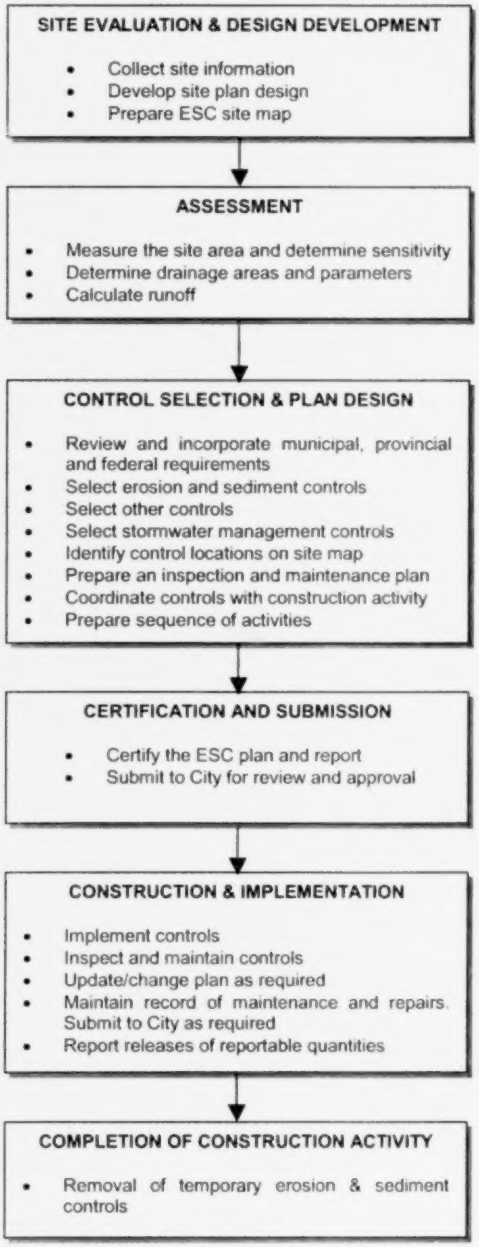
A number of measures can be implemented to mitigate the effects of urban development through careful planning and design. Consideration should be given to:

- limiting development and construction to the least critical areas. Therefore, shorelines, floodplains, natural drainage ways, steep slopes, and erodible soils should be avoided where possible.

- efforts should be made to preserve and utilize natural drainage systems. Impervious surfaces should be minimized to enhance infiltration.

- alternative methods of runoff and stormwater management should be considered to enhance infiltration. This will benefit the normal stream in alleviating the need for additional stream alterations due to additional flows.

Figure 4: Erosion & Sediment Control Plan Development Process



SITE EVALUATION & DESIGN DEVELOPMENT

- Collect site information
- Develop site plan design
- Prepare ESC site map

ASSESSMENT

- Measure the site area and determine sensitivity
- Determine drainage areas and parameters
- Calculate runoff

CONTROL SELECTION & PLAN DESIGN

- Review and incorporate municipal, provincial and federal requirements
- Select erosion and sediment controls
- Select other controls
- Select stormwater management controls
- Identify control locations on site map
- Prepare an inspection and maintenance plan
- Coordinate controls with construction activity
- Prepare sequence of activities

CERTIFICATION AND SUBMISSION

- Certify the ESC plan and report
- Submit to City for review and approval

CONSTRUCTION & IMPLEMENTATION

- Implement controls
- Inspect and maintain controls
- Update/change plan as required
- Maintain record of maintenance and repairs. Submit to City as required
- Report releases of reportable quantities

COMPLETION OF CONSTRUCTION ACTIVITY

- Removal of temporary erosion & sediment controls

The ESC report should include both a written portion and an illustrative portion, which includes maps and details (see **Section 7.0 Technical Requirements**). The written portion should explain and justify the control measures chosen, and include information concerning site conditions, construction schedules, inspection and monitoring schedules, and other pertinent items not contained in the drawings. The drawings should describe where and when the various measures should be installed, the expected performance, and actions to be taken if performance goals are not achieved. The report must be a stand-alone document that can be located on the construction site for use by construction and inspection personnel. As site work progresses, the plan should be modified by the consultant and contractor to reflect changing conditions.

The ESC plan and/or report should consider 12 elements:

- Mark clearing limits
- Establish construction access
- Detain flows
- Install sediment controls
- Stabilize soils
- Protect slopes
- Protect drain inlets
- Stabilize channels and outlets
- Control pollutants
- Control de-watering
- Maintain BMPs
- Manage the project

General principles should consider the following:

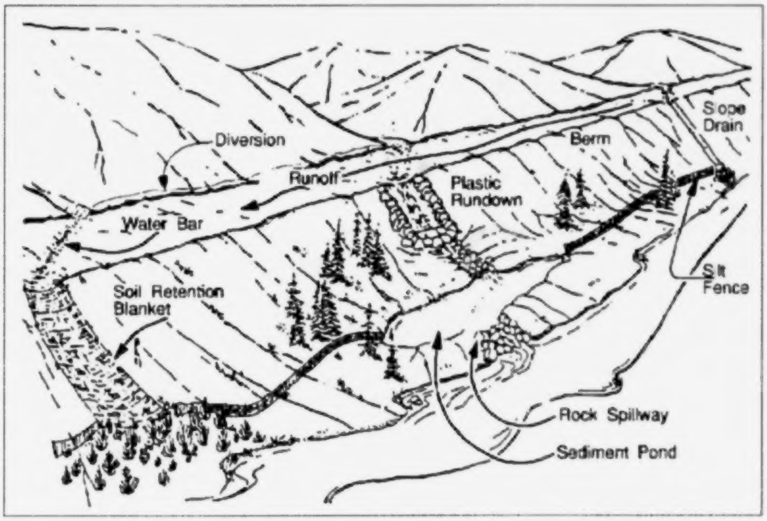
(1) Prevent pollutant release. Source control Best Management Practices (BMPs) should be selected as the first line of defense.
(2) Erosion and sediment control measures, or other BMPs, should be selected based on the site characteristics and the construction plan.
(3) Site drainage and soil conditions should be assessed to determine the most significant factors for the site and planned construction.
(4) Runoff should be diverted away from exposed areas when possible.
(5) Existing vegetation should be preserved.
(6) The extent of clearing and phased construction operations should be limited.
(7) Natural drainage features should be incorporated when possible. Adequate buffers should be used to protect areas where flow enters the drainage system. Keep clean water clean.
(8) Minimize slope length and steepness.
(9) Runoff velocities should be reduced to prevent channel erosion.
(10) Prevent tracking of sediment off-site.
(11) Select the appropriate control measures for control of pollutants other than sediment.

5.0 EROSION AND SEDIMENT CONTROL METHODS

The implementation of erosion and sediment controls measures are not intended as rigid procedures, since it is anticipated that those responsible for the implementation will continue to utilize innovative approaches which best address specific situations. It is important to note that the nature of existing and proposed development, modifications to watercourses, and inherent tolerances in calculations and design techniques, may have significant impacts on the accuracy of outputs and on the preferred approach. Advances in technology will also continue to improve the methods and techniques that are currently employed. It is expected that the implementers will give due recognition to these factors during the decision-making process.

A large number of erosion and sediment control measures are available (see Figure 5). These measures are published in manuals or collections of standards, which describe criteria and specifications in detail. An important step in the erosion control process is the selection of an appropriate method from the variety available.

Figure 5: Example of Erosion & Sediment Control Features



Once an evaluation has been carried out to determine the combined effect of erodibility of the site and sensitivity to sedimentation downstream, then appropriate control methods can be determined.

On all urban construction sites, from small individual building sites to large sub-divisions, the contractor should employ a minimum set of control measures in order to achieve sufficient erosion and sediment control.

The project designer (or appointed designate) should be aware that the review of any erosion and sediment control strategy will examine the suitability of proposed control measures according to site conditions and the degree of control required as a result of the evaluation process. All areas of a site, even those rated as having low erosion potential, will require some "minimum" measure(s) unless the disturbed areas drain to an on-site depression with adequate storage capacity and an overflow outlet. This method of impounding storm flows is a good control feature. However, caution is advised in urban areas where public safety is of greater concern.

Appropriate signage, warning of the hazards of the site, is required for all large sites that contain erosion and sediment control facilities. Fencing may also be required.

These guidelines contain commonly used control measures that have been demonstrated to be effective. A summary list is provided in **Sections 5.3, 5.4 and 5.5.** These lists are provided as a guideline only and should not be interpreted as an exhaustive selection. Following the lists are a series of corresponding standardized description sheets in the section on Standard Specifications for Erosion Control Measures and the section on Standards and Specifications for Sediment Control Measures.

5.1 BEST MANAGEMENT PRACTICES (BMPS)

Best Management Practices, or BMPs, are activities or practices, or a combination of practices, that are designed to prevent or reduce the release of pollutants to receiving waters or streams. BMPs operate by trapping stormwater runoff and detaining it until unwanted pollutants such as sediment, phosphorous and other harmful contaminants are allowed to settle out or be filtered through underlying soils. The trapped pollutants are then removed through periodic maintenance.

Best Management Practices (BMPs) and erosion and sediment control measures are synonymous (i.e. interchangeable). There are generally two types of BMPs that can be used to provide erosion and sediment control: source control BMPs and runoff, conveyance, and treatment BMPs. Source control BMPs help prevent sediment-laden flows from running onto surfaces where pollutants can be picked up. When contaminants are picked up, they should be routed through runoff, conveyance and treatment BMPs. BMPs also include good housekeeping practices.

Source control BMPs include seeding, mulching, sodding, matting, trees and shrubs, and dust control. Runoff, conveyance and treatment BMPs include stormwater channels and ditches, grassed waterways, buffer strips, rock filters and brush barriers, check dams, silt fences, and sediment traps and ponds.

Care should be made in selecting the appropriate BMP or combination of BMPs. Overall education is an integral component of successful design and implementation. It is the designer/consultant's responsibility (or appointed designate) to ensure that all BMPs are properly designed according to site conditions or constraints, and that details are provided on the drawings.

5.2 METHOD OF SELECTION

A large number of erosion and sediment control measures are available. Therefore, selection of specific controls is important to the overall effectiveness and success of the project. The proper selection of specific control methods should consider:

a) The SITE EVALUATION SUMMARY;
b) Season;
c) Design requirements;
d) Construction requirements;
e) Municipal by-laws and guidelines; and
f) Cost.

Since effective implementation of control measures is a site-specific operation, the user may choose any combination of the measures listed; modify the measures listed; or supplement the list with other appropriate measures.

Where possible, the relative effectiveness of the measures has been evaluated with the result that certain measures have been designated "minimum". This designation identifies measures which, if used alone, can be expected to provide only minimum protection. See Tables 7 and 8.

5.2.1 Degree of Control

The degree of control must also be assessed. When a site has low erosion potential and the impact on the downstream water uses is also low, good housekeeping" measures may be sufficient for erosion and sediment control. When the impact and potential for erosion is greater, then further specific control measures will be required. Table 6 should be used to determine the degree of control required.

Tables 7 and 8 indicate the types of control measures and their relative effectiveness in terms of "minimum" requirements. The term "minimum" used in these guidelines relates to the use of one individual control measure where a site evaluation shows negligible impact on the downstream uses.

Where the evaluation shows a potential for greater impact on the downstream water uses, then more than one single measure for a specific control purpose will be required. The number of measures to be used will depend on the severity of potential impact on the downstream water uses.

Where temporary impoundment areas are considered, the size of the facility should typically provide protection for the downstream environment against storms, which, on the average, could occur once every two to five years (i.e. 2 year and 5 year return period storm). Storage volume requirements are quantified in **Section 5.5.2 Impoundment**.

The final test of the degree of control is whether the measures installed have the desired effect. This can only be determined through monitoring their effectiveness in the field (see **Section 6.0 Monitoring and Maintenance**).

5.3 GOOD HOUSEKEEPING PRACTICES

There are many erosion and sedimentation concerns that arise due to construction activities. These include, but are not limited to the following:

a) Mud tracking from construction sites onto adjacent properties and streets
b) Silt and debris washed into the existing storm sewer (or drainage) system
c) Silt and debris transported to receiving watercourses by surface runoff and the sewer system
d) Wind blown dust

However, good housekeeping, erosion and sediment control practices can be employed during construction to minimize and/or eliminate these concerns.

GOOD HOUSEKEEPING PRACTICES will help minimize erosion and sediment concerns, and should be considered when preparing the construction schedule. While some may be impractical under certain conditions, others should be considered based on suitability, practicality and cost effectiveness.

1) Stockpiles should be located away from watercourses, environmentally sensitive areas, drainage courses, ravines, and existing adjacent developments. The stockpiles should be stabilized against erosion immediately following stripping operations. Stabilization can include, but is not limited to, establishment of a cover crop or a hydroseed matrix consisting of seed, fiber bond, and tackifier.

2) All construction vehicles should leave the site at a designated point or points. Gravelling or paving (where practical) of frequently used access roads will help ensure that minimal material such as mud is tracked off-site. The access road should consist of a bed of non-erodible material (i.e. gravel) of sufficient length to ensure that a minimum of material (mud) is tracked offsite onto adjacent municipal streets. Internal haul roads and\or track packs can also be designated and maintained to help reduce offsite tracking. In situations

where mud tracking becomes a major problem, a high-pressure pump and hose installation may be used to provide a washdown facility for truck wheels.

3) When sewers have been installed or are existing, measures should be undertaken to ensure sediment and debris does not get into the municipal sewer system. Both catchbasins and manholes should be protected. This may be accomplished by sealing the openings, setting up sumps or weirs inside the structures, or by providing appropriate inlet protection (filter fences, sediment traps, etc.). A temporary drainage system should be used with appropriate velocity controls and temporary storage areas for sediment control. This will ensure that sediment and debris do not get into the municipal sewer system and into the downstream waterways. Diligent efforts must be taken to ensure that the temporary drainage system does not flood adjacent properties.

4) Where on-site or downstream detention facilities are provided, use can be made of a quantity control facility (through the placing of temporary weirs or check-dams) for sediment control during construction. **(Therefore, all temporary and permanent detention facilities must be constructed prior to the installation of any services on the site or the commencement of earth-moving operations).**

5) Dust control measures should be implemented to prevent wind transport of dust from disturbed soil surfaces. This may be accomplished several ways. Vegetate, hydroseed, or mulch areas that won't receive vehicle traffic. Otherwise, construct wind breaks or screens. The site may also be sprinkled with water or a chemical dust suppressant to control dust; however, care must be taken to prevent the tracking of mud that may result. Otherwise, another effective tool is to reduce vehicle speeds to decrease the amount of dust stirred up.

6) All accumulated sediment and debris should be removed as required. Once construction activities are complete, all related materials and temporary structures should be removed and properly disposed of.

5.3.1 Good Housekeeping Measures for Storm Sewer Protection

During construction, the following "good housekeeping" practices should be undertaken regardless of soil erodibility and any other erosion and sediment control measures undertaken to protect the storm sewer.

1) Special temporary sump manholes with an extended barrel should be provided at special locations throughout the storm system. Catchbasins may be provided on smaller systems. The sumps should be inspected and cleaned frequently.

2) At the downstream end of the site, the last manhole on the storm sewer should have a sump that will retain any large debris. The sump can be cleaned out and filled in with concrete at the end of the project.

3) Small weirs should be built into the pipes at manholes on the sites that are near the outlet for the site drainage. This will provide impounding within the minor system and encourage settlement of the sediment being transported. Care should be taken when removing the weirs that the sediment is not washed into the municipal system.

4) Once the catchbasins have been installed and connected to the minor system, the basins in rear yards, ditches and low activity areas should be buffered using filters on the upstream side.

5.4 EROSION CONTROL MEASURES

Erosion controls are surface treatments that stabilize soil exposed by grading or excavation. Erosion control measures, also commonly referred to as Best Management Practices (BMPs), typically include source controls, vegetative controls and non-structural controls.

Choosing the right erosion control can be confusing and difficult given the wide range of techniques available. Too often, the cost alone determines the erosion control method used. While cost is an important consideration, other factors related to the site should be considered. This includes soil quality, climate, flow velocities and construction activity. In many circumstances, covering the ground as quickly as possible provides the best means of erosion control. Options are available to provide cover during critical periods. This can include mulch, erosion control blankets, and plastic sheeting.

A sound erosion and sediment control strategy should first try to prevent the production of sediment through application of on-site erosion control measures. The two general approaches to achieving this goal are:

a) the protection of exposed surfaces, and
b) the control of runoff

The movement of sediment-laden stormwater is not necessarily a concern if the flow does not leave the site. **(The real problem occurs when sediment-laden flow leaves a site.)**

5.4.1 Protection of Exposed Surfaces

The protection of exposed surfaces from the erosive energy of wind, rain splash, and overland flow should be the primary goal of the project designer (or appointed designate) when selecting appropriate control measures. The use of temporary or permanent vegetative and non-vegetative cover will help provide protection of exposed surfaces. See Table 7 for more information. **It should be noted that *cover* is the single most effective erosion control practice or BMP for preventing erosion.**

Vegetative cover can include seeding, mulching, hydroseeding or sodding, or a combination of these covers. Non-vegetative cover can include rip-rap, gabions, aggregate cover and paving. See **Section 9.0 of City of Calgary "Stormwater Management & Design Manual"** for more information.

5.4.2 Control of Runoff

During construction it will not always be possible or practical to provide surface cover for all disturbed areas. Commonly used methods for protecting exposed ground surfaces include the modification of slope surfaces, the reduction of slope gradients, controlling flow velocity, diverting flows around the affected area, and the providing upstream storage for runoff. See Table 7 for more information.

Runoff control can be accomplished through grassed waterways, stormwater channels and ditches, and stabilization of construction roads and parking areas. **See Section 9.0 of City of Calgary "Stormwater Management & Design Manual"** for more information.

5.5 SEDIMENT CONTROL MEASURES

Sediment controls capture soil that has eroded. While the prevention of initial erosion should be the primary goal, some sediment on construction sites cannot be entirely eliminated. To complement erosion control practices, some form of sediment control should be employed. Generally this can be achieved through filtration of the sediment-laden flows and impounding it to allow settling (see Table 8 for more information). Sediment control measures are also commonly referred to as Best Management Practices and include several structural and non-structural controls. For more information, refer to **Section 9.0 of City of Calgary "Stormwater Management & Design Manual"**.

5.5.1 Filtering

Soil particles suspended in runoff can be filtered through porous media consisting of natural and artificial materials (i.e. vegetative strips, stone filters, man-made fiber filters). See Table 8 for more information. Filtering can be effectively applied to concentrated channels flows at inlets of permanent or temporary drainage systems. This application requires careful maintenance to ensure continued effectiveness since clogging can occur rapidly during periods of sustained high flow.

Filtering is most effective when applied to sheet flow from a wide area; a line

Table 7: Erosion Control Measures

(ADAPTED FROM MICHIGAN DEPARTMENT OF NATURAL RESOURCES 1980)

NAME			APPLICABILITY							COMMENTS	SUGGESTED AS A MINIMUM MEASURE?
			SLOPES	STREAMS AND WATERWAYS	SURFACE DRAINAGEWAYS	ENCLOSED DRAINAGE (INLET/OUTLET)	LARGE FLAT SURFACE AREAS	BORROW AND STOCKPILE AREA	ADJACENT PROPERTIES		
PROTECTION OF EXPOSED SURFACES	VEGETATIVE	SEEDING	•		•		•	•	•	INEXPENSIVE AND VERY EFFECTIVE. STABILIZES SOIL. THUS MINIMIZING EROSION. PERMITS INFILTRATION WHICH REDUCES RUNOFF VOLUME. SHOULD INCLUDE PREPARED TOPSOIL BED.	YES
		MULCHING	•			•	•			USED ALONE TO PROTECT EXPOSED AREAS FOR SHORT PERIODS. PROTECTS SOIL FROM RAINSPLASH. PRESERVES SOIL MOISTURE AND PROTECTS GERMINATING SEED FROM TEMPERATURE EXTREMES.	YES
		SEEDING WITH MULCH	•		•			•	•	FACILITATES ESTABLISHMENT OF VEGETATIVE COVER. EFFECTIVE FOR DRAINAGE WAYS WITH LOW VELOCITY. EASILY INSTALLED ON A SMALL SCALE BY INEXPERIENCED PERSONNEL. SHOULD INCLUDE TOPSOIL BED.	YES
		HYDRO-SEEDING	•				•	•	•	EFFECTIVE ON LARGE AREAS. MULCH TACKING AGENT USED TO PROVIDE IMMEDIATE PROTECTION UNTIL GRASS IS ROOTED. SHOULD INCLUDE PREPARED TOPSOIL BED.	YES
		SODDING	•		•		•	•	•	PROVIDES IMMEDIATE PROTECTION. CAN BE USED ON STEEP SLOPES. EASY TO PLACE. MAY BE REPAIRED IF DAMAGED. SHOULD INCLUDE PREPARED TOPSOIL BED.	YES
	NON-VEGETATIVE	RIP-RAP/RUBBLE/GABIONS	•	•	•					USED WHERE VEGETATION NOT EASILY ESTABLISHED. EFFECTIVE FOR HIGH VELOCITIES OR CONCENTRATIONS. PERMITS INFILTRATION. DISSIPATES ENERGY OF FLOW OF SYSTEM OUTLETS.	
		AGGREGATE COVER					•			STABILIZES SOIL SURFACE THUS MINIMIZING EROSION. PERMITS CONSTRUCTION TRAFFIC IN ADVERSE WEATHER. MAY BE USED AS PART OF PERMANENT BASE CONSTRUCTION OF PAVED AREAS.	YES
		PAVING	•				•			PROTECTS AREAS WHICH CANNOT OTHERWISE BE PROTECTED. BUT INCREASES RUNOFF VOLUME AND VELOCITY. IRREGULAR SURFACE WILL HELP SLOW VELOCITY.	
CONTROL OF RUNOFF		SELECTIVE GRADING AND SHAPING	•				•	•	•	WATER CAN BE DIVERTED TO MINIMIZE EROSION. FLATTER SLOPES EASE EROSION PROBLEMS.	YES
		ROUGHENED SURFACE	•				•			REDUCES VELOCITY AND INCREASES INFILTRATION RATES. COLLECTS SEDIMENT. HOLDS WATER. SEED AND MULCH BETTER THAN SMOOTH SURFACES.	YES
		BENCHES	•					•		REDUCES RUNOFF VELOCITY BY REDUCING EFFECTIVE SLOPE LENGTH. COLLECTS SEDIMENT. PROVIDES ACCESS TO SLOPES FOR SEEDING. MULCHING AND MAINTENANCE.	YES
		ROCK/STRAWBALE DIVERSION BERM	•					•	•	DIVERTS WATER FROM VULNERABLE AREAS. COLLECTS AND DIRECTS WATER TO PREPARED DRAINAGE WAYS. MAY BE PLACED AS PART OF NORMAL CONSTRUCTION OPERATION.	YES
		DIVERSION DITCH	•					•	•	COLLECTS AND DIVERTS WATER TO REDUCE EROSION POTENTIAL. MAY BE INCORPORATED IN PERMANENT PROJECT DRAINAGE SYSTEMS.	
		ENERGY DISSIPATOR	•		•	•				SLOWS RUNOFF VELOCITY TO NON-EROSIVE LEVEL. PERMITS SEDIMENT COLLECTION FROM RUNOFF.	

adjacent to the flow at either the top or toe of an embankment slope will provide sufficient filtering action. Stream banks and the perimeter of regions of high-erosion potential are typical sites where vegetative strips, stone filters and man-made fiber filters are employed to filter out and settle sediment. For more information, refer to **Section 9.0 of City of Calgary "Stormwater Management & Design Manual"**.

The most commonly used filtering method is silt curtains or fences. This method should only be used when there is a small amount of runoff. Otherwise, effectiveness decreases. **Use of strawbales is not recommended for filtering purposes.** Silt fences and curtains are more effective for trapping all particle sizes, depending on the mesh size used.

5.5.2 Impoundment

The impoundment of sediment-laden flows lowers its internal energy and permits the settling of suspended sediment particles. This technique is normally applied to concentrated flow within the permanent or temporary drainage system of a site. See Table 8 for more information.

Traps may be formed through excavation, above ground embankments, or a combination of the two. They are commonly constructed of earth, stone, or silt fence and should reflect a **minimum storage volume of 150 m^3/ha**. **Storage volumes of 250 m^3/ha are recommended where site conditions and construction practices warrant higher sediment trapping.** Correctly constructed and well maintained, sediment traps can be an effective means of minimizing the quantity of sediment that is transported off-site.

Ideally, sediment traps should be located within the site near the sediment source. Only the area exposed to erosion should drain into the trap. Roadside ditches and old drainage channels can also be used as sediment entrapment areas.

Impoundment facilities, or sediment ponds, are similar in function to sediment traps, but provide larger storage volumes. **Sediment ponds should be designed for minimum storage volumes of 250 m^3/ha where possible. This corresponds to the minimum water quality control volume required for permanent facilities.** See **Section C (Sediment Control Measures 7 and 8)** for more information.

Care should be taken when designing significant embankments, since these may have to be designed to Small Dam Standards. A qualified and experienced engineer should design the foundation and embankment, and provide inspection during and after construction. Similarly, the optimization of pond areas and depth to obtain maximum efficiency at least cost done by a qualified engineer.

Table 8: Sediment Control Measures

(ADAPTED FROM MICHIGAN DEPARTMENT OF NATURAL RESOURCES 1980)

NAME		APPLICABILITY							COMMENTS	SUGGESTED AS A MINIMUM MEASURE?
		SLOPES	STREAMS AND WATERWAYS	SURFACE DRAINAGEWAYS	ENCLOSED DRAINAGE (INLET/OUTLET)	LARGE FLAT SURFACE AREAS	BORROW AND STOCKPILE AREA	ADJACENT PROPERTIES		
FILTERING VEGETATIVE	VEGETATIVE BUFFER STRIP	•	•					•	SLOWS RUNOFF VELOCITY. FILTERS SEDIMENT FROM RUNOFF. REDUCES VOLUME OF RUNOFF ON SLOPES.	YES
	FILTER BERM	•	•					•	CONSTRUCTION OF GRAVEL OR STONE. INTERCEPTS AND DIVERTS RUNOFF TO STABILIZED AREAS OR PREPARED DRAINAGE SYSTEM. SLOWS RUNOFF AND COLLECTS SEDIMENT.	YES
	STRAWBALE/ROCK FILTER			•	•			•	INEXPENSIVE AND EASY TO CONSTRUCT. CAN BE LOCATED AS NECESSARY TO FILTER SEDIMENT FROM RUNOFF. STRAWBALES MAY BE USED IN CONJUNCTION WITH SNOW FENCE.	YES
	SOD FILTER			•	•				INEXPENSIVE AND EASY TO CONSTRUCT. PROVIDES IMMEDIATE PROTECTION. PROTECTS AREAS AROUND INLETS FROM EROSION.	YES
	BRUSH FILTER			•	•				USES SLASH AND LOGS FROM CLEARING OPERATIONS. CAN BE COVERED AND SEEDED RATHER THAN REMOVED. ELIMINATES NEED FOR BURNING OR REMOVAL OF MATERIAL FROM SITE.	YES
	SILT FENCE	•		•	•			•	FILTERS SEDIMENT FROM RUNOFF AND ALLOWS WATER TO POND AND SETTLE SEDIMENT.	
IMPOUNDMENT	STRAWBALE/SANDBAG/ EXCAVATED/SEDIMENT TRAP/ SEDIMENT POND		•	•					MAY BE CONSTRUCTED OF A VARIETY OF MATERIALS. COLLECTS AND TRAPS SEDIMENT AND REDUCES VELOCITY OF FLOW. CAN BE CLEANED AND EXPANDED AS NEEDED.	

5.6 TEMPORARY MEASURES VS PERMANENT MEASURES

Sediment and erosion control measures can typically be divided into two groups:

- **Temporary** measures which are used only during the construction phase, and
- **Permanent** measures which are intended for permanent use and should be incorporated into the overall design of the development

Temporary erosion and sediment control measures are typically constructed during the construction phase. The purpose of these temporary measures is to prevent the transport of sediment to streams, wetlands, lakes, drainage systems and adjacent properties. These measures can include but are not limited to: buffer strips, filters (rock or brush), and sediment traps and ponds.

There are a number of permanent structures that can be incorporated for the long-term control of runoff. These structures would not be removed after construction completion but would become part of the overall site stormwater plan through integration into the urban design. These permanent structures include the following:

Wet Ponds and Extended Detention Ponds

Wet ponds can be used to accept additional stormwater runoff from construction activities to reduce downstream erosion and to trap sediments and contaminants. The pond drains must allow the excess water to drain slowly. A number of variations to the basic design could be used ranging from relatively small single basins to multiple interconnected basins. Regular maintenance involving sediment removal would be required to ensure that adequate capacity and drainage is maintained.

Extended detention ponds would allow runoff to be detained through slow release rates. Detention allows the sediment to settle out. Due to the slow release, these ponds are generally designed to be dry between runoff events. However, clogging of the outlet is the main concern due to the slow release rate. Therefore, the outlet should be protected or designed accordingly.

Infiltration Basins and Trenches

These structures are designed to impound water for the purpose of enhancing infiltration. The basins are typically dry. While the ability to trap sediment is high, the life of the structure may be short-lived due to the potential for rapid clogging. A high level of maintenance is required to maintain these structures.

Grassed Swales

Grassed swales act as conveyance channels which enhance sediment removal and increase infiltration. By increasing detention time over the length of the swale (through check dams), sediment removal can be enhanced.

Filter Strips

Filter strips are usually vegetated strips that buffer the development site and the waterway. The strips are generally flat and provide sediment reduction by overland runoff flowing over the strips. However, proper maintenance is required to ensure effective treatment.

Wetlands

Constructed wetlands can also be used for interim sediment removal. The shallow pools provide a suitable growing condition for marsh plants, which in turn provides sediment and pollutant removal through uptake, retention and settling. A sedimentation forebay is required for capturing the sediment-laden runoff to ensure that the main wetland is not adversely impacted by the sediment load. The main wetland is more likely to survive and the forebay allows for easier cleaning. Periodic maintenance is required to remove accumulated sediments. The use or modification of **natural** wetlands is prohibited.

6.0 MONITORING AND MAINTENANCE

Once a combination of erosion and sediment control measures appropriate to the site has been selected, it is important that their effectiveness is monitored, the necessary maintenance be carried out, and there must be a contingency plan for failures. The success of the entire erosion and sediment control strategy will depend upon this, and its importance cannot be overemphasized. All temporary and permanent erosion and sediment control measures shall be inspected, maintained and repaired by the developer/owner, or an appointed designate, during the construction phase as needed to ensure continued performance. **As a minimum, all construction sites should employ good housekeeping practices (see Section 5.3).**

6.1 INSPECTIONS

All erosion and sediment controls must be inspected every 7 days and following heavy rainstorms or snowmelt events. All disturbed areas of the site, material storage areas, entrance and exit roads, and **all** erosion and sediment controls must be inspected. The controls must be in good operating condition until the area they protect has been completely stabilized and the construction activity complete. **Inspection is the responsibility of the developer/owner or his designate, which could be the contractor and/or consultant.** Inspection procedures may vary depending on the season (i.e. spring/summer compared to fall/winter). To enhance knowledge and understanding, the City of Calgary will endeavor to provide ESC training for contractors, builders, consultants, and developers/owners on a regular basis. The developer/owner, or designate, must ensure compliance to regulatory requirements.

The developer/owner or his designate is ultimately responsible for the adequacy, proper installation, and maintenance of the erosion and sediment control measures. However, the City of Calgary will inspect construction sites for compliance. This in no way eliminates the need for the developer/owner or designate to provide their own inspectors or conduct their own inspections. Inspections may also be conducted by the Provincial and Federal Inspectors to ensure compliance. See Section 2.0 Regulatory Requirements.

Projects in natural watercourses, rivers and along lake shores may additional require permits from Alberta Environment, Federal agencies, and/or the City. Refer to **"Stormwater Management & Design Manual" by Wastewater and Drainage** for Approval Requirements.

Pursuant to sections 99 and 100 of the *Environmental Protection and Enhancement Act*, releases of substances that cause or may cause an adverse affect on the environment must be reported. Release of substances includes sediment-laden runoff from construction sites. Reporting is required under the provincial *Release Reporting Regulation* (117/93). See **Section 2.2.2**. Prohibited substances and releases into storm drainage systems are provided in the *Wastewater and Storm Drainage Regulation* (119/93). See **Section 2.2.3**.

6.2 MAINTENANCE AND REPAIRS

Maintenance and repair of the control measures are the responsibility of the developer/owner, or the appointed designate. A schedule of planned maintenance activities is required with the submission of the Erosion and Sediment Control Plan and report and should be followed. **When implemented controls are insufficient or not working properly, changes to the ESC Plan and Report must be made to ensure continued compliance.**

Some measures such as strawbale barriers, silt fences and inlet protection devices will require periodic replacement and/or removal of accumulated sediment. **Sediment basins (traps and ponds) will require periodic sediment removal when the design storage level is one third to one half full.**

Damage or deficiencies to control measures should be corrected as soon as practicable after an inspection, but in no case later than 7 days after the inspection.

6.3 RECORDS

The developer/owner, or his designate, must maintain an inspection record of any maintenance, damages or deficiencies of erosion and sediment control measures. An inspection and report must be undertaken every 7 days and following heavy rainstorms or snowmelt events. The same document can be used to record maintenance and repairs undertaken after the inspection. It is the responsibility of the developer/owner, or designate, to design and implement the inspection and maintenance record. The record must be signed by the developer's/owner's inspector and must be available for review by the City's inspectors at any time. ***Failure to complete inspection/maintenance record(s), follow erosion and sediment control practices, or adequately maintain ESC controls, will require bi-weekly submission of the inspection and maintenance record to the City's Development Inspector for review.***

Refer to **Appendix D** for examples of Maintenance Check Sheets.

7.0 TECHNICAL REQUIREMENTS

This section outlines the report and construction drawing requirements for Erosion and Sediment Control. These requirements must be addressed in applications for stripping and grading. In general, the erosion and sediment control package should include details of the selected control measures, the areas in which they are to be used, the "good housekeeping" practices that are to be employed, and the procedures for monitoring and maintenance. The developer/owner shall meet the requirements of The Erosion and Sediment Control Guidelines of the City of Calgary and submit an Erosion and Sediment Control Report and/or Plan (as required) to obtain permission to strip and rough grade the proposed development.

7.1 EROSION & SEDIMENT CONTROL REPORTS

An **Erosion and Sediment Control Plan** should be prepared for **all** construction projects. For sites smaller than 2 ha (5 acres), this will consist of identifying minimum control measures known as good housekeeping practices, and where practicable, implementing erosion and sediment controls to control runoff on-site. Sites larger than 2 ha require the submission of an **Erosion and Sediment Control Report**. During construction, the plan should be modified as required to suit field conditions and changing variables.

i. The ESC Report should include both a written portion and an illustrative portion, which includes maps and details. The written portion should explain and justify the control measures chosen, and include information concerning site conditions, construction schedules, inspection and monitoring schedules, and other pertinent items not contained in the drawings. The drawings should describe where and when the various measures should be installed, the expected performance, and actions to be taken if performance goals are not achieved. A schedule of planned maintenance activities should also be included. A copy of the report, along with a copy of the construction drawings, must be located on the construction site for use by construction and inspection personnel. As site work progresses, the ESC Plan should be modified by the contractor to reflect changing conditions. Refer to **Appendix C Minimum Requirements for Erosion & Sediment Control Reports**.

ii. An inspection, maintenance and repair record(s) must also be kept at the construction site for review by construction personnel, inspectors, consultants and developers/owners. If erosion and sediment control practices are not being followed, or maintenance and/or repair of ESC controls is being neglected, then the record must be submitted bi-weekly to the City's Development Inspector for review.

7.1.1 Subdivision

For construction sites larger than 2 ha, an Erosion & Sediment Control Plan and Report must be developed and submitted to The City of Calgary Urban Development Department (Development Inspector) to obtain a stripping and grading permit. Wastewater & Drainage will further review the report. Refer to **Appendix C** for report requirements. The plan may be modified to suit changed site conditions and effectiveness.

7.1.2 Drainage & Site Servicing Plan

Site servicing plans refer to all commercial, industrial and multi-family parcels. For construction sites larger than 2 ha, an Erosion & Sediment Control Plan and Report must be developed and submitted to The City of Calgary Urban Development Department (Development Inspector) to obtain a stripping and grading permit. Wastewater & Drainage will further review the report. Refer to **Appendix C** for report requirements. The plan may be modified to suit changed site conditions and effectiveness.

For sites smaller than 2 ha, good housekeeping practices must be identified and employed, and where practicable, erosion and sediment controls must be implemented to control runoff on-site. While an Erosion & Sediment Control report is not required, erosion and sediment control details must be provided on the drawings for review and approval.

7.1.3 Special Projects

All special projects and contracts are required to conform to Erosion and Sediment Control requirements, whether they are designed within the City by other business units or through external consultants. For construction sites larger than 2 ha, an Erosion & Sediment Control Plan and Report must be developed and submitted to The City of Calgary Urban Development Department (Development Inspector) to obtain a stripping and grading permit. Wastewater & Drainage will further review the report. Refer to **Appendix C** for report requirements. The plan may be modified to suit changed site conditions and effectiveness.

For sites smaller than 2 ha, good housekeeping practices must be identified and employed, and where practicable, erosion and sediment controls must be implemented to control runoff on-site. While an Erosion & Sediment Control report is not required, erosion and sediment control details must be provided on the drawings for review and approval.

7.2 CONSTRUCTION DRAWINGS

A copy of the Erosion & Sediment Control Plan (drawing) and pertinent details must be included in the Construction Drawing set (preliminary and final sets) for all Subdivisions, Drainage & Site Servicing Plans, and Special Projects and Contracts. This is to ensure that the ESC information is readily and easily accessible to all personnel, including inspectors and contractors. Erosion and sediment control is everyone's responsibility.

8.0 REFERENCES

1. Alberta Agriculture, Food and Rural Development, *Alberta Horticultural Guide*, 1994

2. City of Calgary, *Stormwater Management & Design Manual, Wastewater & Drainage*, December 2000.

3. M.T.C. Ontario, *Erosion and Sediment Control*, M.T.C. Drainage Manual, Chapter F.

4. M.T.C. Ontario, *Erosion Control and Practices* – J.J. Armstrong.

5. M.T.C. Ontario, *Guidelines for Analyzing Surface Water Sensitivity to Erosion and Sedimentation.*

6. State of Michigan, *Soil Erosion and Sedimentation Guidebook.*

7. State of Virginia, *Erosion and Sediment Control Handbook.*

8. U.S. Department of Agriculture and Soil Conservation, *Engineering Field Manual.*

9. U.S. Department of Agriculture, *Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas.*

10. U.S. Environmental Protection Agency, *Erosion and Sediment Audiovisual Training Program.*

11. U.S. Soil Conservation Service, *National Engineering Handbook – Specifications for Construction Contracts.*

12. U.S. Soil Conservation Service, *National Handbook of Conservation Practices.*

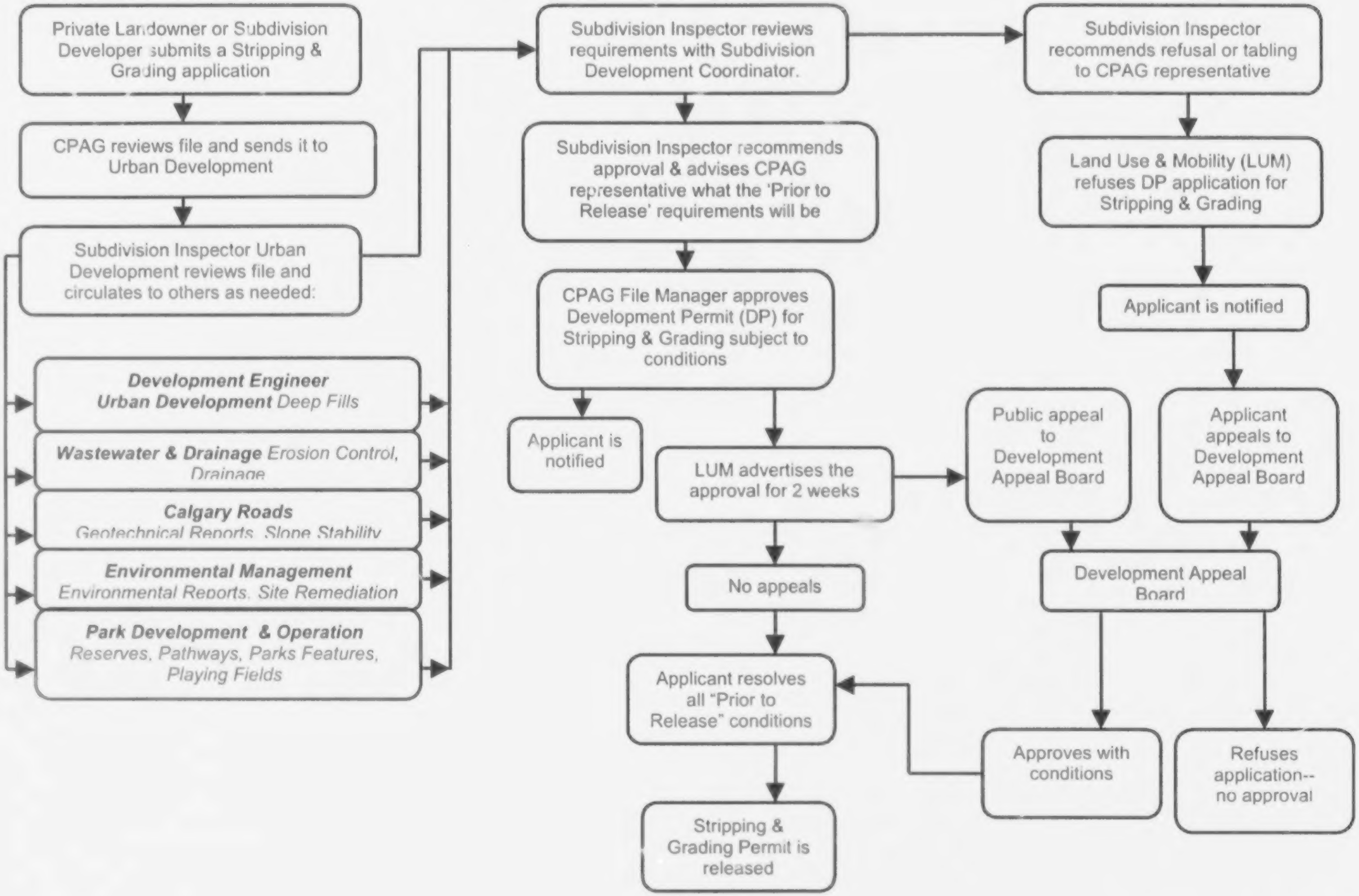
13. U.S. Transportation Research Board, *No. 70 Design of Sedimentation Basins.*

14. U.S. Transportation Research Board, *No. 221 – Erosion Control During Highway Construction.*

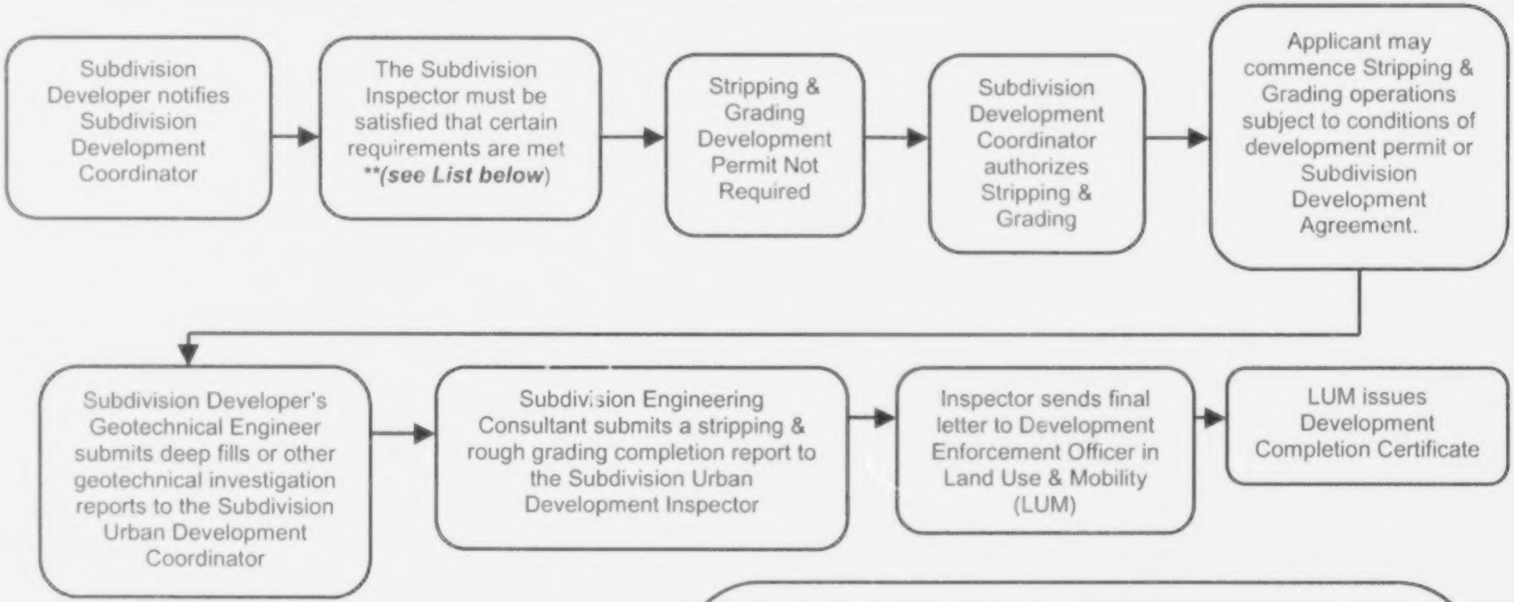
15. Washington State Department of Ecology, *Stormwater Management in Washington State-Volumes I, II, IV and V*, 1999

APPENDIX A PROCESS FLOW CHARTS FOR STRIPPING & GRADING

Processing Stripping & Grading Permits Through the Urban Development Division


Private Landowner or Subdivision Developer submits a Stripping & Grading application
CPAG reviews file and sends it to Urban Development
Subdivision Inspector Urban Development reviews file and circulates to others as needed:
Development Engineer Urban Development *Deep Fills*
Wastewater & Drainage *Erosion Control, Drainage*
Calgary Roads *Geotechnical Reports, Slope Stability*
Environmental Management *Environmental Reports, Site Remediation*
Park Development & Operation *Reserves, Pathways, Parks Features, Playing Fields*
Subdivision Inspector reviews requirements with Subdivision Development Coordinator.
Subdivision Inspector recommends approval & advises CPAG representative what the 'Prior to Release' requirements will be
CPAG File Manager approves Development Permit (DP) for Stripping & Grading subject to conditions
Applicant is notified
LUM advertises the approval for 2 weeks
No appeals
Applicant resolves all "Prior to Release" conditions
Stripping & Grading Permit is released
Subdivision Inspector recommends refusal or tabling to CPAG representative
Land Use & Mobility (LUM) refuses DP application for Stripping & Grading
Applicant is notified
Public appeal to Development Appeal Board
Applicant appeals to Development Appeal Board
Development Appeal Board
Approves with conditions
Refuses application-- no approval

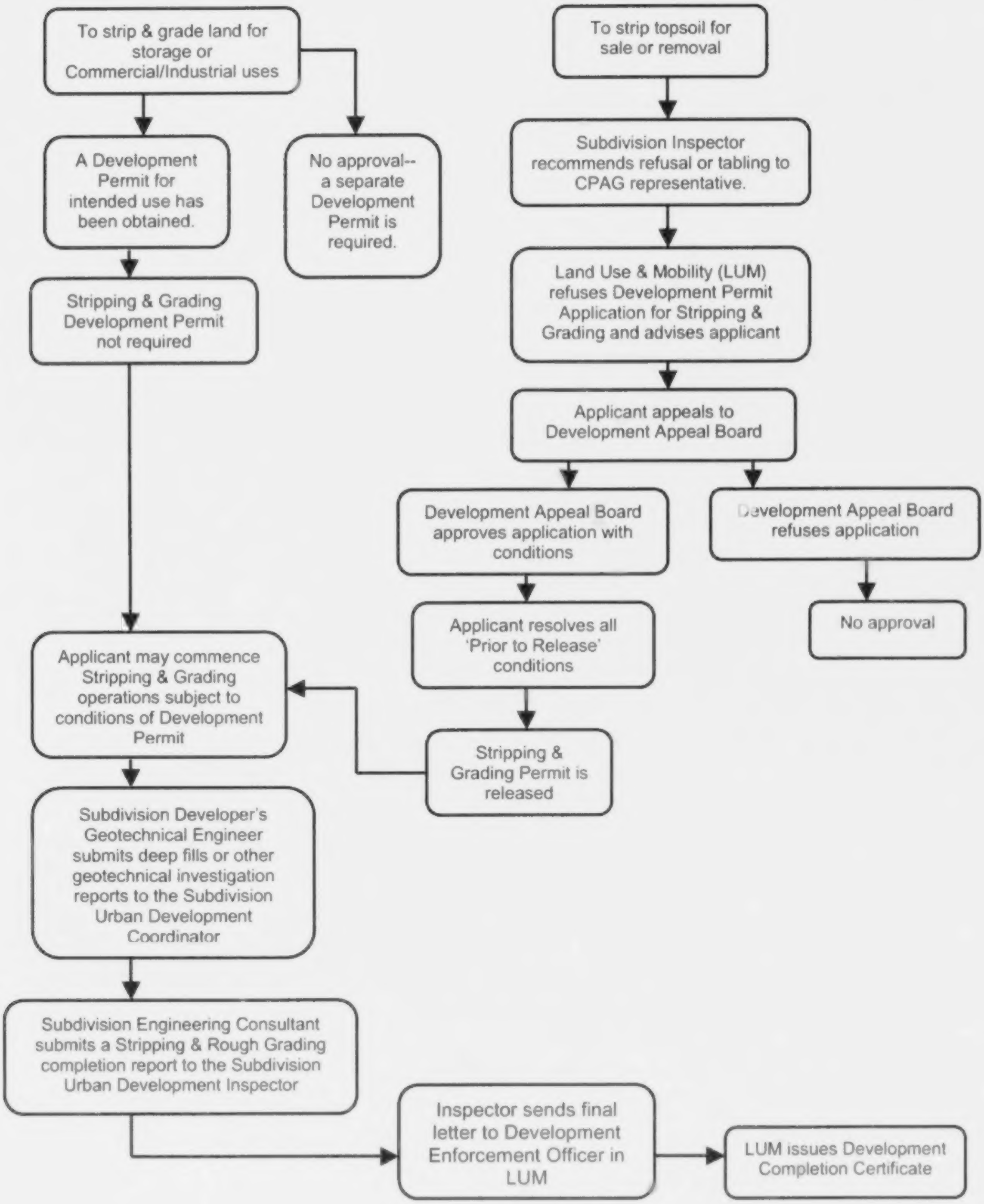
Processing Stripping & Grading Permits Through the Urban Development Division: *Stripping & Grading Under a Subdivision Development Agreement*


Subdivision Developer notifies Subdivision Development Coordinator
The Subdivision Inspector must be satisfied that certain requirements are met ***(see List below**)
Stripping & Grading Development Permit Not Required
Subdivision Development Coordinator authorizes Stripping & Grading
Applicant may commence Stripping & Grading operations subject to conditions of development permit or Subdivision Development Agreement.
Subdivision Developer's Geotechnical Engineer submits deep fills or other geotechnical investigation reports to the Subdivision Urban Development Coordinator
Subdivision Engineering Consultant submits a stripping & rough grading completion report to the Subdivision Urban Development Inspector
Inspector sends final letter to Development Enforcement Officer in Land Use & Mobility (LUM)
LUM issues Development Completion Certificate

***Requirements (where applicable):*

- Stripping & grading boundaries
- Loam stockpile locations are acceptable to the Calgary Park Development & Operations, & owners of the property
- Performance letter of credit submitted
- Special clauses accepted by developer
- Owner's indemnity letters provided
- Stripping & grading agreement executed
- Any necessary plans and reports are approved:
    - Outline plan
    - Cut & fill plan
    - Geotechnical report
    - Overland drainage plans
    - Erosion control report
    - Stripping boundary
    - Loam stockpile locations
    - Construction drawings
    - Subdivision conditions
    - Environmental clearances

Processing Stripping & Grading Permits Through the Urban Development Division: *For Purposes Other Than Subdivision Development or Building*


To strip & grade land for storage or Commercial/Industrial uses
A Development Permit for intended use has been obtained.
No approval-- a separate Development Permit is required.
Stripping & Grading Development Permit not required
To strip topsoil for sale or removal
Subdivision Inspector recommends refusal or tabling to CPAG representative.
Land Use & Mobility (LUM) refuses Development Permit Application for Stripping & Grading and advises applicant
Applicant appeals to Development Appeal Board
Development Appeal Board approves application with conditions
Development Appeal Board refuses application
No approval
Applicant resolves all 'Prior to Release' conditions
Stripping & Grading Permit is released
Applicant may commence Stripping & Grading operations subject to conditions of Development Permit
Subdivision Developer's Geotechnical Engineer submits deep fills or other geotechnical investigation reports to the Subdivision Urban Development Coordinator
Subdivision Engineering Consultant submits a Stripping & Rough Grading completion report to the Subdivision Urban Development Inspector
Inspector sends final letter to Development Enforcement Officer in LUM
LUM issues Development Completion Certificate

Development Permit Requirement List
Stripping & Grading

1. Copy of the certificate of title(s).
2. Copies of any restrictive covenants, easements and city caveats registered on the title(s).
3. A letter of authorization from the registered owner of the land.
4. Colour photographs of the site and surrounding area (photos should provide a visual account of the site and the surrounding area, including any buildings or unique topographical features). *Photographs mounted to fit in a development permit file (i.e. 8.5" x 11" or 11" x 14").
5. Fee.
6. A completed potential site contamination "Acknowledgment and Disclosure" statement (standard form is available from the Development & Building Applications customer service counter).
7. Five (5) copies of a site plan, with a minimum scale of 1:500, showing:
    - North arrow
    - Municipal address (e.g. street address)
    - Legal description (e.g. township/range/etc., or plan/block/lot)
    - Property lines
    - Existing survey control stations/markers
    - Details of loam stockpiles, including height, width, length and volumes
    - All easements, road rights-of-way setback lines, utility rights-of-way, overhead utility lines and underground utilities, if any
    - The means by which all storm water in and from subject lands will be controlled and disposed of, including how drainage from its natural route will be controlled
    - Any intended stripping & grading on adjacent lands, including details of edge conditions, backsloping requirements and areas to be reloamed, seeded and maintained until natural conditions are restored
    - Any special topographical features or site conditions (escarpments, break-of-slope, unstable areas, etc.
    - Any bus zones and bus shelters adjacent to the site, showing bus zone aprons, sign posts, parking meter posts and street poles
    - the significant vegetation areas and trees on the site that are to be removed and that are to remain

8. Five (5) copies of an 8 x 11 area map showing:
    - The area to be stripped & rough graded outline in red
    - The locations of any stockpiles of stripped loam outlined in green

9. Two (2) copies of a cut & fill plan
    - Note: a cut & fill plan is required even where no cut & fill is proposed, in order to provide documented confirmation that no cut & fill activity is taking place

10. Two (2) copies of a deep fills report
    - A deep fills report is required where fill is being provided to a depth of greater than two metres

11. Phasing plan
    - A phasing plan indicating areas expected to be developed during the current year and the types of soil stabilization proposed for areas not to be developed until the following years

12. Cross-sections
    - Cross-sections may be required to provide more information on the impact of the stripping & grading on adjacent properties. Cross-sections should show both the existing and the proposed grade on the site, on adjacent sites and on any adjacent city streets (datum points are required to ensure the accuracy of the plans).

13. Material required after application has been submitted
    - The applicant is advised that after an initial review of the application has taken place, additional information may be requested, including:
        - A revised site plan showing fencing, including snow fencing required at the boundary of any environmental reserve land
        - An "erosion control report" dealing with erosion control measures where necessary
        - Environmental reports and clearances

In addition, the Development Authority may require any material considered necessary to properly evaluate the proposed development (as stated in Section 10(1)(b) of the Land Use Bylaw). However, normally an application will be complete if the material outlined above is provided. The clarity, legibility, precision and neatness of the plans submitted helps us to save time in the processing of the application. Staff are instructed not to accept incomplete application material or plans of poor or unprofessional drafting standards.

APPENDIX B TYPICAL STRIPPING & GRADING PERMIT CONDITIONS

A **Development Permit** is required for all construction sites having a land use designation above R2 development. Within the existing development permit review process, site erosion control requirements will be reviewed and applied as conditions of the development permit.

Land is not permitted to be stripped or graded without a development permit or a Subdivision Development Agreement. This includes any form of land disturbing activities, and can include road grading.

Prior to issuance of the **stripping and rough grading permit**, the following conditions must be agreed to between the Developer and the City of Calgary. A **Developer** is defined as any party undertaking stripping and grading or any form of land disturbing activity. This can include, but is not limited to, developers, landowners, contractors, consultants, and other City departments. The City is defined as the City of Calgary.

Typical Prior to Release Conditions

The Developer must contact the undersigned:

a) submit the $___________ Letter of Credit performance security for the stripping and grading;

b) submit the Certificate of Insurance required;

c) submit the letter under Company Seal as per Item #15 below;

d) submit a copy of the Province of Alberta approval required for any Transportation Utility Corridor (T.U.C.) Encroachment as per their T.U.C. Policy (copy attached);

e)
  - i) submit cut and fill plans identifying those areas being filled more than two meters. (2 copies)
  - ii) submit a Deep Fills Report for those areas being filled more than two meters. The report must be prepared by a qualified Geotechnical Engineering Consultant in accordance with the Guidelines for preparing Geotechnical Reports," and is also to make recommendations on any development restrictions, i.e. bearing certificates, special foundation designs that may be necessary to ensure the integrity of structures constructed on fill areas.

f) applicant is to install all signage requirements as per Special Conditions #2c and #3.

g) submit to the undersigned two copies of a drainage plan and Erosion and Sediment Control Report prepared in accordance with the requirements of the Guidelines for Erosion and Sediment Control satisfactory to Wastewater & Drainage showing measures for control of erosion and sedimentation, both during the stripping and grading, and after completion of grading and site rehabilitation; (all Erosion Control features are to be in place prior to commencement of Stripping and Grading operations, and must be maintained regularly and as necessary, and water truck(s) must be on site at all times.)

h) applicant will submit a letter stating that all affected utility companies have been contacted regarding the relocation or disposition of that utility.

i) submit plans showing any intended stripping and grading operations on the adjacent lands, including highlighted details of edge conditions over 0.5 meters, backsloping requirements and areas to be re-loomed, seeded and maintained until natural conditions occur;

j) identify the owners of all lands adjacent to the stripping and grading and provide written documentation from the affected property owners giving permission to access such lands, including City owned rights-of-way used for backsloping or other purposes and where the stripping and grading boundary abuts other property owners, cross sections must be submitted;

k) submit a phasing plan indicating areas expected to be developed during the current year, and type of soil stabilization proposed for areas not to be developed until the following years;

l) submit details of loam stockpiles including height, width, length and volume and identify a location for basement excavation.

m) a letter from Parks Development & Operations and/or the School Board affected (if required) approving the location of the loam stockpile on an MR or MSR site, including other conditions that may be required.

n) submit a letter from Calgary Roads, approving the stockpiling of loam on interchange areas, or grading adjacent to exiting or proposed roadways, including other required conditions.

o) applicant must contact Calgary Waterworks (Phone 268-4989) and make arrangements for "water supply" during the stripping and grading process.

Special Conditions Permit Requirements:

1. Only the Lands shown outlined in red on the attached plan shall be stripped and rough graded.
2. Prior to the commencement of stripping and rough grading of the Lands, the Developer shall:

   (a) notify the Subdivision Inspector of the Urban Development Division 24 hours in advance and arrange a site meeting with the Developer's Consultant and Excavation Contractor. (Phone: 268-8223; Cell: 804-9698)

   (b) erect fencing and provide other measures satisfactory to Parks Development & Operations to ensure the stripping and grading does not encroach into ER land where applicable, and

   (c) erect "Private Property" and "No Trespassing" signs on the perimeter of the Lands, stating the Developer's name and the phone number of a representative.

3. The stripped loam shall be stockpiled in the location shown outlined in green on the attached plan and the loam stockpile shall be neat in appearance, free from any hazardous condition and treated to prevent soil erosion from wind and rainfall and be posted against dumping and designated "Private Property", "No Trespassing" and "No Unauthorized Personnel Beyond this Point".

4. The Developer shall be responsible for controlling noxious weeds and excessive vegetative growth within the development site.

5. The loam pile shall be removed by _______date__________, unless an extension of time is given by Urban Development prior to the said date. Extension applications must be requested in writing in advance of the above date or the request will be denied and removal procedures will be initiated.

6. Soil Screening operations of any Loam Stockpile must have prior approval from Urban Development and all of the said operations will remain the responsibility of the permit holder and will operate under the following conditions:

   (1) only existing Loam located on the Lands is to be screened. No offsite materials is to be brought on the Stripping and Grading Area unless a valid Development Permit or Development Agreement allowing for such soil screening operation is in place;
   (2) the said operations are to be shut down when adverse wind-blown dust conditions prevail;
   (3) all access roads within and adjacent to the Stripping and Grading Area must be cleaned by the Developer as necessary as per City of Calgary Streets Bylaw 16-1-2;
   (4) internal haul roads and working surface areas in and around the Lands must be watered regularly and as necessary; and
   (5) the Stripping and Grading Area must be rehabilitated at conclusion of the project through appropriate grading and re-seeding or by completion of the development of the Stripping and Grading Area.

7. No grading, filling or excavation is permitted within utility and road rights-of-way, under any overhead utility lines, or over any underground utilities, unless prior written authorization has been obtained from the utility agencies concerned.
8. The Developer shall submit any modifications to the drainage plans and Erosion and Sediment Control Report that may be necessary from time to time for various reasons including, but not limited to, portions of the Lands becoming developed, or adjacent lands becoming developed, or drainage and or erosion control facilities that may require rerouting or redesigning.
9. The Developer at no expense to the City, before, during and after the stripping and grading and development of the area, shall implement the

drainage control guidelines for the control and disposal of all stormwater in and from the Lands and stormwater which may be cut off from its natural drainage route by the development including, but not limited to, inlet protection to any adjacent stormwater sewer system and will get the necessary Drainage Authorization Permit from Wastewater & Drainage (Sr. Inspector-Al Bowerman 268-2313) for any offsite pumping into storm sewers waterways or ravines.

10. The Developer or the owner of the Lands being stripped and rough graded, shall employ appropriate measures to control any dust, particularly in the vicinity of highways or occupied dwellings, to ensure traffic safety and minimize dust nuisance complaints from the public, and to minimize drainage, soil erosion, soil instability and other problems arising from stripping, rough grading, the loam stockpile and all operations related thereto.
11. If, during construction of the development, the applicant, the owner of the development site, or any of their agents or contractors becomes aware of any contamination:
    (a) The person discovering such contamination shall forthwith report the contamination to Alberta Environment, Calgary Health Services and The City of Calgary, and
    (b) The applicant shall, prior to the approval of a development completion permit, submit a Phase 2 Environmental Site Assessment, prepared by a qualified professional, to Alberta Environment, Calgary Health Services and The City of Calgary, and
    (c) If required to do so by Alberta Environment or Calgary Health Services, applicant shall submit to Alberta Environment or Calgary Health Services a remediation plan or risk management plan (Phase 3 ESA), prepared by qualified professional, and acceptable to Alberta Environment and Calgary Health Services and provide a copy to the City of Calgary.

If submission of a Phase 3 ESA has at any time been required, a Development Completion Permit shall not be approved until a qualified professional has submitted to the Development Officer a letter, in a form satisfactory to the Development Officer, certifying that the physical components identified in the Phase 3 ESA have been installed.

If no contamination is discovered during construction of the development the applicant shall, prior to the approval of a Development Completion Permit, submit to the Development Officer a letter, in a form satisfactory to the Development Officer, certifying that no contaminants were discovered during construction of the development.

12. The Developer, at its sole expense, shall rehabilitate the adjacent lands to the satisfaction of the owners immediately after completion of the stripping and rough grading of the adjacent lands.

13. The Developer, at his/her own expense, and to the satisfaction of The City, shall rehabilitate in a timely manner any offsite areas or operations, storm water runoff, soil erosion, soil instability, sedimentation, dust or other problems which may arise from the stripping and grading, and shall employ the use of gravel pads to curb track-out onto the street and reduce or stop activity when the site has excessive dust emissions.

14. The Developer shall either develop or rehabilitate all of the lands stripped and rough graded within two (2) years from the date of Development Permit approval, unless an extension to this deadline is granted by Urban Development. Such application to review and extend the deadline shall be made by the Developer in writing to Urban Development for approval at least 30 days prior to expiry.

15. The Developer shall submit a letter under corporate seal indemnifying and saving harmless The City and owners of adjacent properties or such other affected parties from any losses or damages which the City and owners of adjacent properties or such other affected parties may sustain as a result of the storm water runoff, soil erosion, soil instability, sedimentation, loam stockpile, dust and any other problem that may arise from the stripping and rough grading of the Lands. In addition, the Developer, at his/her own expense, shall take corrective action(s) deemed necessary to rectify the problem(s) and to do so in a timely manner to the satisfaction of The City.

16. In the event the Developer fails to maintain the Lands or rehabilitate any of the Land stripped or disturbed, or to remove the loam stockpile or to remedy the dust, drainage, soil instability, soil erosion, sedimentation, nuisance or hazardous conditions, The City upon 30 days' written notice to the Developer may enter upon the Lands and rectify any deficiencies at the Developer's expense

17. Notwithstanding Clause 15, in the event of an emergency, The City shall have the right, but not the obligation, to enter upon the Lands and rectify any dust, storm water runoff, soil instability, soil erosion, sedimentation, grading, dust, nuisance or hazardous condition(s) at the Developer's sole cost. The City, within three (3) working days following such work, is to give written notice to the Developer as to what work was undertaken during the emergency.

18. All costs incurred by The City in exercising its rights under items 14, 15 and 16 shall be due and payable by the Developer within 30 days of receipt of the invoice of such work. In the event the Developer fails to pay The City, The City has the right to recover its costs from the (performance security) Letter of Credit posted by the Developer.

19. The Developer, if applicable, shall submit a Geotechnical Report for Deep Fills (in accordance with the Policy I Geotechnical Report Requirements) by a qualified Geotechnical Engineering Consultant. The report, amongst other things, shall certify that all the fill material was placed and compacted in accordance with the City of Calgary Specifications and Standards and the report shall also make recommendations or special

foundation designs, necessary to ensure the integrity of any structure constructed in fill areas.

20. Stripping and Rough Grading Report shall be submitted by the Consulting Engineer to Urban Development certifying that rough grading was in compliance as set out in the "Consulting Engineer Field Services Guidelines."
21. A Development Completion Certificate will not be issued until all stripping and grading, loam stockpile removal, and site rehabilitation requirements have been completed to the satisfaction of Urban Development and Planning and Building (Senior Development Authority).
22. The Developer shall pay to The City a fee to replace any or all survey control station/markers that have been destroyed or damaged due to the development of the area.

The replacement charges, per survey controls station, are as follows:

1st Order (Deep Bench Mark)	$6,000.00
High Precision Network Marker (H.P.N.)	$4,000.00

(NOTE: Prices are subject to change)

APPENDIX C MINIMUM REQUIREMENTS FOR EROSION & SEDIMENT CONTROL REPORTS

MINIMUM REQUIREMENTS FOR EROSION AND SEDIMENT CONTROL REPORTS

Reporting Requirements	Mapping Requirements
1. Location and Site Characteristics	
• Describe the location of the proposed development. Include legal description of the site and a reference to adjacent properties and landmarks. • Describe existing land use: - general topography (slopes and slope lengths within the site) - vegetation - soil types (particle sizes, erodibility) - extent and nature of development - drainage patterns - critical areas within the proposed development site that have potential for serious erosion or sediment problems • Identify neighbouring areas such as streams, lakes, residential and commercial areas, reserves, parks and roads that might be affected by the land disturbance.	• Provide location plan showing: - legal land description; and - adjacent properties (streams, lakes, residential and commercial areas, reserves, parks and roadways). • Provide contour plans of existing area and tabulation of slopes and slope lengths. • Indicate the location of trees, shrubs, grass and unique vegetation. • Show the different soil types within the proposed development. • Show the kinds of development on adjacent properties. • Topographic maps should have a sufficient contour interval to determine drainage patterns. Show the drainage divides and flow directions for each drainage area. • Show critical areas within or near the development.
2. Proposed Development	
• Provide a general description of the proposed development with a brief description of the nature and purpose of the land disturbing activity. • Indicate the area and amount of grading proposed for each stage of grading. • Describe the permanent stormwater management system and the use of these facilities for sediment control during the construction period. (Permanent stormwater management facilities require an amending approval by Alberta Environment prior to use for sediment control.)	• Show the limits of clearing and grading for each phase of the development. Each boundary line should be identified as to the timing and duration of disturbances. • Show the drainage divides and flow directions for each drainage area after development and show the changes resulting from grading. Include a contour plan of the finished grades at an appropriate scale (1:2000). • Indicate the location and sizes of permanent storm drain inlets, pipes, outlets and other permanent drainage facilities such as swales, waterways, etc.
3. Erosion & Sediment Controls	
• Determine runoff quantities. • Provide a description of the methods that will be used to control erosion and sediment transport on the site. Provide detailed design information and calculations as required. Stabilization of soils should be the first line of defense. • Identify **temporary** and **permanent** control methods. • Indicate good housekeeping practices. • Show the location, height, and volume of stockpiles. - indicate erosion control measures used to control sediment runoff from the stockpiles. • Indicate the types and scheduling of individual erosion control measures, including interim or short-term measures (less than 45 days duration). • Clearly indicate the measures to control sediment export off the development site. • Describe how the site will be stabilized after construction is completed.	• Indicate the locations, types and sizes/dimensions of the proposed temporary and permanent erosion and sediment control measures including ponds/sedimentation basins and inlet protection. • Show types, locations and dimensions of erosion and sediment control measures on a plan map, for each phase of construction. • Provide details of ESC measures as required. • The location and size of each stockpile should be indicated and annotated with the volume and height. • Show the locations and dimensions of silt fences, sedimentation traps/ponds, berms, etc. • Clearly indicate the measures which will be maintained following construction. • Indicate if bedrock will be encountered during grading.
4. Inspection & Maintenance	
• Provide a schedule of regular inspections and expected repairs of erosion and sediment control devices. • Record changes made to ESC Plan due to changing conditions.	• Update ESC Plan with revised erosion and sediment control measures.

The Erosion and Sediment Control Report must address the following issues:

1. Project Description

Brief description on nature and purpose of the land disturbing activity and the amount of grading involved. Also included is the legal description of the property and a reference to adjacent properties and landmarks.

2. Existing Site Conditions

Existing site topography, vegetation and drainage.

3. Adjacent Areas

Description of neighbouring areas, such as streams, lakes, storm sewers, residential and commercial areas, reserves, parks and roads that might be affected by the land disturbance.

4. Soils

A brief description of soils on the site, including erodibility and particle size distribution.

5. Critical Areas

Description of areas within the development site that have potential for serious erosion or sediment problems.

6. Slopes and Slope Lengths Within the Site

7. Erosion and Sediment Control Measures

A description of the methods that will be used to control erosion and sediment on the site.

8. Permanent Stabilization

Description of how the site will be stabilized after construction is completed. A phasing plan of the stripped area; to be receded and the expected dates will be required.

9. Maintenance

A schedule of regular inspections and repairs to erosion and sediment control devices.

10. Stockpile Information

All stockpile heights, volumes and erosion control plans.

11. Overland Flow Storage

All storage areas must reflect a minimum storage volume of 150 m^3/ha. Storage volumes of 250 m^3/ha are recommended where site conditions and construction practices warrant higher sediment trapping.

12. Internal Haul Road

The applicant will identify an internal haul road for use during construction and maintenance schedule.

MAPS

The following information should appear on “one” or “more” plans or maps.

1. Existing Contours

Existing elevation contours of the site at a sufficient interval to determine drainage patterns.

2. Preliminary and Final Contours

Proposed changes in existing elevation contours for each stage of grading. A cut/fill plan showing existing and proposed contours.

3. Existing Vegetation

Location of trees, shrubs, grass and unique vegetation.

4. Soils

Boundaries of different soil types within the proposed development.

5. Critical Areas

Area within or near the proposed development with potential for serious erosion or sediment problems.

6. Existing and Final Drainage Patterns

A map showing the dividing lines and flow direction for the different drainage areas before and after development.

7. Limits of Clearing and Grading

A line defining the boundary of the area to be disturbed.

8. Stockpile Data

Stockpile locations must be approved. Consideration will include proximity to existing homes.

9. Erosion and Sediment Control Measures

Location, names and dimensions of the proposed temporary and permanent erosion and sediment control measures. All surface drainage must be filtered or run through "sediment control" features before leaving the site.

10. Storm Water Management System

Location of permanent storm drain inlets, pipes, outlets and other permanent drainage facilities (swale, waterways etc. c/w sizes of pipes and channels). Volume, depth, overflow rates and route the flow will follow after overtopping the sediment basins.

11. Details of Dust Control Measures to Address Wind Erosion.

DETAILS

1. Detailed Drawings

Enlarged dimensioned drawings of such key features as sediment basin risers, energy dissipaters and waterway cross sections.

2. Seeding & Mulching Specs

Seed, fertilizing and mulching rates in lbs/acre; kg/ha and application procedures.

3. Maintenance Program

Inspection schedule, spare material needed, stockpile location and treatment method, weed control, details for sediment removal and disposal.

4. Signs

Project name, Developer, Consultant, Contact names on a clearly visible sign for public to contact in case of problems originating from the subject site.

OTHER

1. **Calculations of Assumptions**
2. **Other information may be required/necessary for specific sites.**
3. **Provide phasing and cover details for areas that have been stripped but not developed.**
4. **All peripheral sediment control features must be in place before actual stripping begins.**

APPENDIX D MAINTENANCE CHECK SHEETS

INSPECTION CHECK SHEET

Sheet ___of ___

Project Name: ____File No. __________

Inspection Date: _______________Time:____________Inspected by: _________________________

STAGE OF CONSTRUCTION

___ Pre-Construction Conference
___ Clearing and Grubbing
___ Rough Grading
___ Building Construction
___ Finish Grading
___ Final Stabilization

INSPECTION CHECKLIST

Yes	**No**	**NA (not applicable)**	
{ }	{ }	{ }	Have all denuded areas requiring temporary or permanent stabilization been stabilized? Seeded? **yes/no** Mulched? **yes/no** Gravelled? **yes/no**
{ }	{ }	{ }	Are soil stockpiles adequately stabilized with seeding and/or sediment trapping measures?
{ }	{ }	{ }	Does permanent vegetation provide adequate stabilization?
{ }	{ }	{ }	Have sediment-trapping facilities been constructed as a first step in stripping and grading?
{ }	{ }	{ }	For perimeter sediment trapping measures, are earthen structures stabilized?
{ }	{ }	{ }	Are sediment basins installed where needed?
{ }	{ }	{ }	Are finished cut and fill slopes adequately stabilized?
{ }	{ }	{ }	Are on-site channels and outlets adequately stabilized?
{ }	{ }	{ }	Do all operational storm sewer inlets have adequate inlet protection?
{ }	{ }	{ }	Are stormwater conveyance channels adequately stabilized with channel lining and/or outlet protection?
{ }	{ }	{ }	Is in-stream construction conducted using measures to minimize channel damage?
{ }	{ }	{ }	Are temporary stream crossings of non-erodible material installed where applicable?
{ }	{ }	{ }	Is necessary restabilization of in-stream construction complete?
{ }	{ }	{ }	Are utility trenches stabilized properly?
{ }	{ }	{ }	Are soil and mud kept off public roadways at intersections with site access roads?
{ }	{ }	{ }	Have all temporary control structures that are no longer needed been removed?
{ }	{ }	{ }	Have all control structure repairs and sediment removal been performed?
{ }	{ }	{ }	Are properties and waterways downstream from development adequately protected from erosion and sediment deposition due to increases in peak stormwater runoff?

Comments:

____

____

____

____

____

____

Verbal/Written notification given to: ____

Report by: ____**Date:**______________

EROSION AND SEDIMENT INSPECTION LOG

Site: ______ **Contractors on Site:** ______

Heavy Equipment on Site: ______ **Activities on Site:** ______

Date: ______ **Weather:** ______ **mm of rain in last week:** ______

Note condition of the following measures and sediment levels where applicable:

MEASURE		CONDITION/LOCATION	SEDIMENT LEVEL	ACTION REQUIRED YES/NO	TYPE OF ACTION	ACTION COMPLETED (DATE)	INITIALS
Silt fences							
Temporary Storage Facilities							
Outlet of Temporary Storage Facilities							
Interceptor Swales							
Steeper Slopes							
Cover of Rough Grades							
Catchbasins Filtering Controls							
Dust Control							
Mud Tracking							
Debris Control							

Other Comments (Summarize):

______

______

______

______

Inspectors Signature: ______ **Inspectors Name:** ______

SECTION B

BMP STANDARDS AND SPECIFICATIONS FOR EROSION CONTROL MEASURES

EROSION CONTROL STANDARD 1
SEEDING

INTRODUCTION

Seeding refers to the establishment of plant cover on disturbed areas by applying seeds of annual or perennial plants. The seeds are drilled or broadcast, either mechanically or by hand, depending upon site conditions. Grasses and legumes are commonly used in seed mixtures. Fertilizer, mulch and tackifier are often applied immediately with seeding. Seeding can provide long-term, temporary or permanent stabilization of disturbed areas. The cost of seeding a disturbed area is relatively low and its effectiveness on a long-term basis is quite high.

APPLICATION

The use of seeding as an erosion control measure can only be undertaken during or immediately preceding the growing season. Seeding is used on sites where long-term control is required over a time period of approximately six months. Seeding will not provide an immediate plant cover, and bare soil will persist until plants have developed unless Hydroseed Matrix is applied. Seeding is most appropriate in flat areas and on slopes less than 3H:1V, where equipment accessibility is not limited. Seed mixtures must be selected to suit the site conditions. Factors affecting plant growth include climate, soils, topography, land use and planting season. Site conditions will determine the application rate and mixture of seeds used.

DESCRIPTION

Grasses and legumes are generally used in seed mixtures. Grasses are highly adaptable to various site conditions and provide a dense and lasting ground cover. The fibrous root system of grasses anchors the soil and allows surface water to infiltrate more rapidly.

Legumes are commonly used in combination with various grasses. They are important because of their ability to fix nitrogen and to make it available for plant growth. Some species of legumes have large tap roots that enhance both soil stabilization and infiltration.

INSTALLATION

Site Preparation

To establish a good catch of vegetation, proper seedbed preparation is very important. The soil must be modified to provide the optimum environment for seed germination and seedling growth. Seedbed preparation includes surface roughening and fertilizing

The surface soil must be loose enough for water infiltration and root penetration. Top layers of compacted soil should be loosened by discing, raking or other acceptable means prior to seeding.

A soil test should be completed to determine the nutrient and pH requirements. Soil tests may be conducted in the field using an appropriate soil testing kit, however, it is preferable to have the soil tested by a soil testing laboratory. The soil sample must be taken from the top 10 cm of the final graded substrate including any additional incorporated topsoil. The final pH of the soil should range from 6 to 7. If a soil test is not feasible, a fertilizer of ratio 1:4:4 N-P-K (Nitrogen-Phosphorous-Potassium) should be applied at a rate of 0.45 to 0.68 kg of nitrogen/100m^2.

Seeding

A seed drill or brillion seeder may be used under conditions of adequate moisture on areas suitable for the operation of machinery. Mulch is not mandatory if the seed is covered with soil or a seed drill is used. This method uses a low seeding rate and will give the best germination.

In broadcast seeding, seed is applied to the soil surface and is not cultivated into the soil. The seeding rate is higher than in seed drilling. A mulch is necessary to protect the seed and prevent it from being washed or blown away during germination. The mulch is applied after seed and fertilizer application (see **Erosion Control Standard 2 Mulching**).

The success of seeding operations will depend on adequate knowledge of site conditions including soil drainage, texture and pH. Whenever possible, expert advice should be sought concerning site conditions.

MAINTENANCE

Seeded areas should be maintained according to location and plan. High maintenance areas will be mowed frequently, irrigated, fertilized, and the weeds intensively controlled.

Low maintenance areas will receive proportionally less maintenance input. However, even low maintenance areas should be watered and fertilized to ensure that the seeding is effective and a stand of vegetation is established. The first year after seeding is critical. Water application rates should be heavy but controlled to prevent runoff.

Small areas of failure must be reseeded promptly. If the stand has less than 40% cover, the choice of plant material and quantities of soil amendments should be re-evaluated.

SPECIFICATIONS

1. Canada No. 1 seed shall be used for all seeding operations. Seed should be tested within six months of date of sowing. Seed mixes in or adjacent to natural areas should be reviewed by Park Development & Operations to ensure that undesirable species are not unintentionally introduced.

2. Seed application rates will be dictated by site conditions, climate, soils, topography, land use, planting season, and seed types. In general, seeding rates shall be at least 15 kg/ha on good agricultural soil. In areas where seed catch may be difficult due to poor nutrient status in the soil, seeding rates shall be at least 20 kg/ha.

3. When using a seed drill or brillion seeder, grasses and legumes shall not be planted more than 1 cm deep.

4. Bacterial innoculants must be used when seeding with legumes. A specific innoculant shall be used for the legume being seeded in accordance with supplier's recommendations for specific products.

5. Fertilizer, in lieu of a soil test, shall be 1:4:4 fertilizer. It shall be applied at a rate of 45 to 68 kg of nitrogen/ha depending upon site conditions. Fertilizer use should be carefully controlled as this may increase nutrient loading to receiving streams if runoff is not controlled properly.

6. Seeding shall occur during periods when germination can be guaranteed and plants have sufficient time to become established before the end of the growing season (i.e. May 15 – June 1 and/or August 15 – September 15, plus or minus). Seeding should not occur after the 50 per cent frost probability date for the site.

7. When broadcast seeding, mulching is required.

8. Mulching of the exposed soil is required if seeding is carried out after the date specified in which fall seeding should not be carried out.

EROSION CONTROL STANDARD 2
MULCHING

INTRODUCTION

Mulching refers to the application of organic material or other suitable substances to the soil surface to conserve a desirable soil property or to promote plant growth. Mulches conserve soil moisture, prevent surface compaction, reduce runoff and surface erosion, control weeds, help establish plant cover, and provide fiber in a hydroseed matrix.

APPLICATION

Mulching can be used to provide both short and long-term erosion control. Mulches may be used in areas that are graded or not graded, and with or without the use of plant material. They may be applied immediately following broadcast seeding (or planting), or with seed application to provide suitable soil conditions for optimal plant growth. Mulching may also be used for long-term erosion control in the absence of plant material or seeding.

The choice of materials for mulching will be based on the type of soil to be protected, site conditions, season, costs, availability of materials, and the availability of labour and equipment. Non-biodegradable mulches should not be used in areas where they may become a source of litter.

DESCRIPTION

Organic mulches include straw, raw wood fiber, peat moss, wood chips, bark, pine needles, compost and verdyol. Chemical mulches include a wide range of synthetic spray-on materials marketed to stabilize and protect the soil surface. These can be emulsions or dispersions of vinyl compounds, asphalt, rubber or other substances that are mixed with water before application. Chemical mulches may be used to bind other mulches or with wood fiber in a hydroseed slurry.

Organic Mulches

(a) **Straw** – Straw refers to the stalks or stems of small grains (mostly wheat) after drying and threshing. Straw is packed in bales and is available in bulk quantities. It should be relatively free of weeds. Loose straw is very susceptible to windblow. When tacked down, it is highly suitable for promoting good grass cover quickly. It may, however, be a fire hazard.

(b) **Raw Wood Fiber** – This is a conglomeration of cellulose fibers 4 mm or longer extracted from wood. These fibers usually require a soil binder. Wood fiber is used in hydroseeding operations where it is applied as part of a slurry. It should not be used for erosion control during hot periods in the summer or late fall seeding unless it is used in association with another suitable mulch. It may be sprayed on top of an installed net and is well suited for tacking straw mulch on steep slopes.

(c) **Peat Moss** – This material consists of partly decomposed mosses accumulated under conditions of excessive moisture. It is usually available dried and compressed. It should be free from coarse material. Peat moss is a useful soil conditioner when mixed with the soil. When dry and placed on top of the soil, it may be susceptible to windblow.

(d) **Wood Chips** – These are small, thin pieces of sliced wood slabs and edgings produced as a by-product in sawmills. Wood chips decompose slowly. They are suitable around individual plants and for areas that will not be closely mowed. Wood chips are resistant to windblow.

(e) **Bark Chips, Shredded Bark** – These are slices and scrapings of tree bark produced as a by-product of timber processing. Suitable for areas that will not be closely mowed, they have a good moisture holding capacity and are resistant to windblow.

(f) **Pine Needles** – These leaves of pine trees should be air-dried and free from coarse material. They decompose slowly and are suitable for use with plants that prefer acid soils. Pine needles are resistant to windblow.

(g) **Compost of Straw Manure** – These are organic residues and straw that have been piled and allowed to undergo biological decomposition until relatively stable. Compost or straw manure should be well shredded, free from excessively coarse material and not wet. It has good moisture-holding capacity and is very suitable as a soil amendment. It should be resistant to windblow when moist.

Chemical Mulches

Chemical mulches, such as acrylic co-polymers and emulsifications, are generally part of a matrix of seed, bondable fiber and tackifier. Chemical mulches are typically applied with a hydroseeder. All applications should be applied according to site conditions and recommended product specifications.

INSTALLATION

Site grading and required sedimentation control practices should be undertaken prior to mulching. Surface roughening, fertilizer application and liming should occur prior to mulching if seeding is included (see **Erosion Control Standard 1 Seeding**).

The method of mulch application depends on the type of mulch being used. Organic mulches can be applied by hand or machine. Chemical mulches are usually applied with sprayers designed for asphalt emulsions or water.

With most mulches, steps must be taken to anchor the mulch or bind it to the soil. Methods include the use of chemical binders, asphalt spray, mulch netting, peg and twine, and punching or tracking.

Chemical binders are usually the same products that are used as chemical mulches (see **Erosion Control Standard 7 Chemical Stabilization**). They can be used in a hydroseeder or applied separately.

Asphalt spray must be used with straw, wood chips or compost. Asphalt must be thin enough to be blown from spray equipment. Mulch netting made from jute, wood fiber or plastic (see **Erosion Control Standard 8 Nets and Matting**) may be used with many organic mulches. Netting is often used on critical areas such as creek banks at water crossings. The installation of netting is usually labour-intensive.

Peg and twine is also labour intensive but suitable for small areas. Wooden pegs are placed every 120 cm in all directions. Twine is stretched between the pegs in a criss-cross within a square pattern.

Punching is suitable for straw mulch. The straw is cut into the soil surface with a square-edge spade in contour rows. Tracking involves driving a bulldozer over the straw. The cleats of the bulldozer cut the straw into the soil surface.

MAINTENANCE

All mulches should be inspected periodically, especially after rain storms, to check for erosion and decomposition. Where needed, additional mulch should be applied.

SPECIFICATIONS

1. Application rates for mulches are as follows:

Straw	3000 to 4500 kg/ha
Raw wood fiber	1000 to 2000 kg/ha
Peat moss	10 to 30 m^3/ha
Wood chips	9,000 to 13,000 kg/ha
Bark chips, shredded bark	90 to 140 m^3/ha
Pine needles	4000 to 5000 kg/ha
Compost or straw manure	18,000 to 5000 kg/ha
Chemical mulches	Follow manufacturer's recommendations

2. If applying straw by hand, divide the areas to be mulched into 100 m sections and place the straw in each section to facilitate uniform distribution.

3. Chemical mulches shall be applied at manufacturers recommended rates. They shall not be applied during very hot periods or during periods of frost.

4. When anchoring mulch with an asphalt emulsion, apply asphalt at 5400 L/ha. Do not use heavier applications as it may cause the straw to “perch” over rills.

EROSION CONTROL STANDARD 3
HYDROSEEDING

INTRODUCTION

Hydroseeding refers to the establishment of plant cover on distributed areas by applying in one operation, seed of annual and perennial plants along with fertilizers, mulch, soil adhesives and water. Seed, fertilizer, mulch, soil adhesives and water are mixed together in a holding tank to form a slurry. The slurry is held in suspension by continuous agitation. Using a high-pressure pump, the mixture is sprayed on the area to be re-vegetated.

APPLICATION

Hydroseeding may be used to provide soil stabilization in disturbed areas where it is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials. Hydroseeding enables the quick re-vegetation of very steep, rocky or gravelly slopes where re-vegetation by any other method would be extremely difficult and expensive. It can also be used in areas where conventional methods such as broadcast seeding, seed drilling or sodding are applied.

The site must be accessible to the hydroseeding unit (mounted on a truck). The hoses from the hydroseeding unit have a maximum range of about 150 m.

DESCRIPTION

Seed, fertilizer and mulch should be carefully selected to conform to site conditions. Soil characteristics, climatic conditions, topography, land use and planting season should be considered when determining materials to be used in hydroseeding. The required amount of materials will again depend upon site conditions. If needed, soil stabilizing materials can be incorporated into the slurry.

Since the success of hydroseeding operations will depend on adequate knowledge of site conditions (including soil drainage, texture and pH) expert advice should be sought concerning methods for different circumstances.

INSTALLATION

Since hydroseeding often is used to re-vegetate hard to reach areas (i.e. steep slopes, dry sites with little or no topsoil), site preparation is not always possible. In accessible areas, however, surface roughening may be very advantageous prior to hydroseeding.

The surface soil must be loose enough for water infiltration and root penetration. When the areas to be hydroseeded are compacted, the soil surface should be loosened by discing, raking or other acceptable means prior to hydroseeding.

Seed, fertilizer, soil adhesives, mulch and water should be mixed together in the holding rank of the hydroseeding unit to form a slurry. The filling capacity of the holding tank usually varies between 440 and 660 litres. The slurry must be agitated continuously throughout the entire spraying process to ensure consistency. A special heavy pump produces the required pressure to spray the mix on the area to be re-vegetated. The mobile spray fund of the hydroseeding unit has a range of about 60 m. Hoses from the hydroseeding unit have a maximum range of about 150 m.

Hydroseeding is a relatively fast operation since seed, mulch and fertilizer are applied in one step. Between 4000 and 20,000 m^2 can be hydroseeded by one unit each day, depending on site conditions.

MAINTENANCE

During the first year after seeding, it is necessary to water and fertilize according to weather and soil conditions. Water application rates should be heavy but controlled to prevent runoff. Fertilizer will need to be applied only if it was not adequate at the time of seeding.

Small areas of failure must be reseeded promptly. If larger areas of failure occur, the method of hydroseeding should be re-evaluated.

SPECIFICATIONS

1. Seed, mulch, and fertilizer application rates will depend on site conditions. (see **Erosion Control Standards 1 and 2 for Seeding and Mulching**).

2. If seeding with legumes, the bacterial innoculant will need to be applied at 4 times the normal rate.

3. The slurry shall be applied to the area to be re-vegetated in a layer 0.2 to 2 cm thick. In rocky areas and areas with little topsoil, the layer may be thicker. If more than one application is necessary the first layer shall be dried or settled before the second layer is applied.

4. Hydroseeding shall not be permitted during periods of heavy rain, strong winds or frost.

EROSION CONTROL STANDARD 4
SODDING

INTRODUCTION

Sodding refers to the use of permanent grass sod to cover and stabilize disturbed areas. It is used to rapidly establish plant cover in areas where complete cover of the soil surface is required without delay or where seeding may not be practical (i.e. drainage ways) to establish grass. The use of sod is generally much more expensive than seed; however, it has an immediate effect.

APPLICATION

Sod may be used to protect graded surfaces from water and wind erosion where adequate topsoil or fertilizer and water can be provided. It is best used for areas that are steep or require immediate protection, or at locations where aesthetic considerations are a priority. Sod may be maintained or left unmanaged.

DESCRIPTION

Sod may be Nursery or Field Sod. It may be composed of one or more species/cultivars of grasses and may contain associated plants such as legumes. Field Sod is sod not specifically produced for sale as turf and is generally not certified as to composition or degree of weed infestation.

INSTALLATION

Site Preparation

Sod must be laid on fine-graded areas where close and complete contact between the sod roots and the soil/substrate surface can be maintained. The surface must be clear of debris, stones, plant remains, trash and other objects greater than 5 cm in diameter. The surface must be graded smooth and be free of air or water pockets.

Before sod is laid, a soil test should be completed to determine the nutrient and pH requirements. Soil tests may be conducted in the field using an appropriate soil testing kit. However, it is preferable to have the soil tested by a soil testing laboratory. The soil test consists of a sample from the top 10 cm of the final graded substrate including any additional incorporated topsoil.

Where a soil test is not feasible, a fertilizer of ratio 1:4:4 N-P-K should be applied at a rate of 0.45 to 0.68 kg of nitrogen/100 m^2. Soil amendments must be incorporated into the top 7 to 15 cm of the soil/substrate surface using normal agricultural tillage practices. The site must be fertilized within 48 hours of prior to laying the sod.

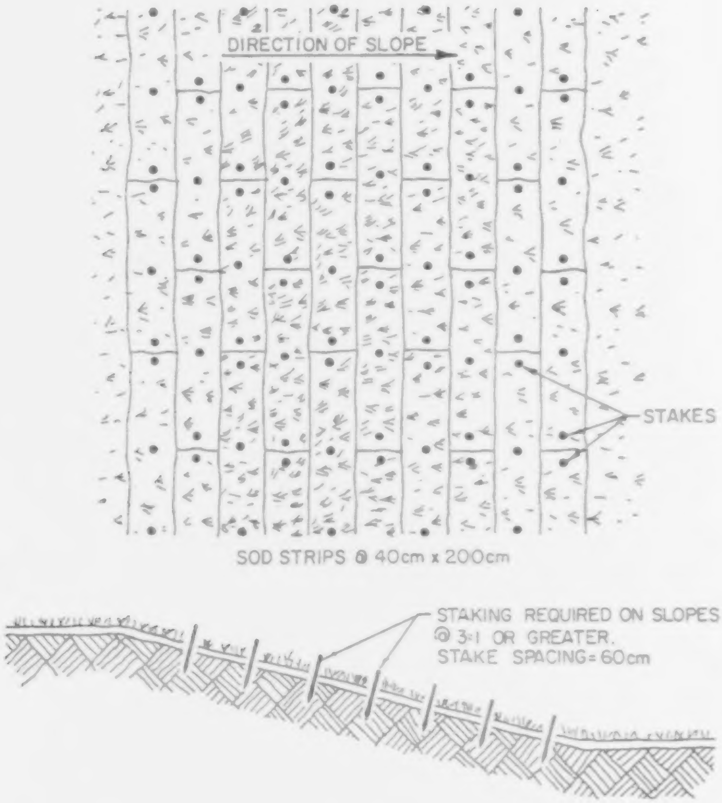
Sod should not be laid on sites without topsoil. Topsoil should be spread evenly across the site to a depth of 7 to 15 cm and incorporated into the surface of the substrate by discing or cultivating.

Installation

Successful installation requires the use of freshly cut healthy sod. Sod must not be laid on frozen ground surfaces. During dry, hot periods, the ground surface must be cooled by irrigation before the sod is laid. Sod must be rolled or tamped firmly to ensure good soil contact. Freshly installed sod must be irrigated to moisten soil to a minimum depth of 10 cm.

The installation of sod on steep or potentially unstable slopes requires that sod stripes be placed with the long axis perpendicular to the fall of the slope. Sod must be placed such that all joints form an interlocking pattern of strips across the slope. Each sod strip must be pegged with a suitable wooden stake or metal staple 15 to 25 cm long inserted flush with the sod surface, using one stake or staple on center every 60 cm (see Figure 6).

Figure 6: Sodding


DIRECTION OF SLOPE
STAKES
SOD STRIPS @ 40cm x 200cm
STAKING REQUIRED ON SLOPES @ 3:1 OR GREATER.
STAKE SPACING=60cm

MAINTENANCE

Sod should be maintained by fertilizing, irrigating, mowing and weed control depending on location and plan. Sod shall be irrigated to maintain field capacity moisture levels to a minimum depth of 10 cm for the first week after installation. It should be fertilized as indicated by the soil test or the following schedule may be used:

Nutrient Rate
(kg/10 m^2)

Time	Nitrogen	Phosphorous	Potassium
Early Spring	0.5	0.25	0.25
Early Summer	0.5	-	-
Mid Summer	0.5	-	-
Early Fall	0.5	0.25	0.25

Sod that is to be maintained by mowing shall not be mowed within two weeks after installation. Afterwards, it shall be mowed systematically throughout the growing season beginning in the spring after the grass is 6 to 8 cm high and ceasing when cold weather in the autumn restricts growth. No more than 35 to 40 per cent of the shoot shall be removed at any one cutting; turf grass is maintained best at between 3 to 7 cm in shoot height. Grass clippings should remain on the sod after mowing unless they accumulate at greater than 1 cm depth when they should be removed.

Weeds may be controlled in sod that is to be mowed or left unmanaged according to accepted horticultural practices.

SPECIFICATIONS

Nursery sod or field sod may be used to control erosion:

Nursery Sod

1. If nursery sod is used, it shall meet the requirements of the Canadian Nursery Trades Association for No. 1 Kentucky Bluegrass cultivars. It shall be cut from a stand two years of age and shall be weed-free (no more than two broad-leaved weeds or ten other weeds/40 m^2). Sod mixes in or adjacent to natural areas should be reviewed by Park Development & Operations to ensure that undesirable species are not unintentionally introduced.

2. The mowing height limit shall be 3.5 to 6.5 cm.

3. The soil portion of the sod shall not exceed 4.0 cm.

4. Sod shall be cut from fertile, loamy soil, be well-rooted, disease-free and of uniform texture. It should not be lifted during excessively hot, dry periods and should be moist enough to remain viable during storage, transport and installation.

5. Sod shall be cut to standard dimensions or as required by the planting plan. (Standard dimensions are approximately 40 cm wide by 200 cm long to form 0.8 m^2 coverage).

6. Sod shall be rolled unless otherwise specified and shall be in a condition such that it may be handled and installed without tearing or breaking

7. Sod shall be harvested within 36 hours preceding installation.

EROSION CONTROL STANDARD 5
RIP-RAP

INSTALLATION

Rip-rap made up of large, loose angular stones will provide a durable erosion resistant ground cover. The purpose of placing rip-rap is to:

i) protect the soil surface from erosive forces;
ii) slow the velocity of runoff; and
iii) stabilize slopes

APPLICATION

Stone rip-rap is durable, heavy and flexible and is the most popular material used in constructing revetments. The popularity is due to the fact that rip-raps are flexible as the stone rip-rap adjusts to changes resulting from erosion beneath the stone and the rough surface of the stones dissipate part of the energy of the flowing water. The most common locations for rip-rap are stream channel banks, slopes of dikes, inlet and outlet structures carrying water and bridge abutments.

INSTALLATION

Where erosion potential is high, rip-rap should be placed as soon as possible after the soil has been disturbed. For inlet or outlet protection, rip-rap should be placed before the flow has an opportunity to create erosion. See **Section D BMP Specification Details.**

SPECIFICATIONS

Rip-rap shall be made up of a graded mixture such that 50 per cent of the mixture by weight shall be larger than the d50 size selected by the designer. The largest size shall be 1-1/2 times the d50 size while the smallest size shall be approximately 2 cm. The designer should be aware that smaller sizes of rip-rap are more vulnerable to vandalism.

The minimum thickness of the rip-rap layer shall be 1-1/2 times the maximum stone diameter, but not less than 15 cm.

For flow stabilization projects, the angle of repose of the rip-rap stones shall be greater than the slopes to be protected. A practical maximum slope for rip-rap is 2H:1V.

Filter blankets, which are placed between rip-rap and the soil to be protected, are made up of gravel or man-made filter cloth. The function of the filter layer is to:

i) separate the soil from the rip-rap;
ii) redistribute the forces acting on the soil;
iii) provide drainage facilities

The erosive force of flowing water is greater in bends than in straight channels. Therefore, rip-rap sizes for bends should be larger.

EROSION CONTROL STANDARD 6
AGGREGATE COVER

Aggregate refers to the use of crushed stone or gravel applied directly to the soil surface. Aggregate secures the soil, reduces erosion and provides a continuous all-weather cover.

APPLICATION

Aggregate as a cover may be used to stabilize soil surfaces and to reduce erosion by construction traffic (especially during wet weather), in wet areas or on slopes. It is used to stabilize large, flat disturbed areas where the site is being prepared for paving or where the use of vegetation is not feasible (such as on a temporary roadway parking area). The use of aggregate to reduce erosion of permanent roadways during construction helps to minimize the amount of regrading necessary between the initial grading and permanent stabilization. A granular blanket of aggregate placed evenly over the surface of slopes will stabilize erosive soils. It is particularly suitable for areas where ground water emerges through the surface soil. The granular blanket of aggregate provides a stable, free-drainage slope material.

INSTALLATION

When aggregate is used as a means of erosion control on temporary access roads and parking areas, the roadbed or parking area surface shall be cleared of all objectionable material, including all vegetation and roots. Grades should be sufficient to provide adequate drainage. The contour of the natural terrain should be followed to the maximum extent possible. For quick stabilization, aggregate should be applied immediately after the sites have received their initial grading.

Where aggregate is used as a means of slope erosion control, the erosive soils must be prepared and smoothed so that the stones will remain in place. Aggregate must be placed evenly over the surface to provide a stable, free-draining slope material.

MAINTENANCE

Periodic improvements with new gravel, usually a top dressing, may be required on temporary and permanent roadways and on parking areas. Slopes should be checked for washouts after storms. Any damage must be quickly repaired.

SPECIFICATIONS

1. On temporary roadways and parking areas, a 15 cm to 20 cm course of crushed granular aggregates shall be applied to the site immediately after grading.

2. Crushed aggregates shall consist of 20 mm crushed rock or gravel composed of hard, durable, uncoated, cubical fragments.

3. Crushed aggregates composed of crushed slag produced from iron blast furnace slag or blended nickel slag shall **not** be used as a means of erosion control in or near a watercourse or on steep or wet areas, including slopes, due to the potential for heavy metal contamination.

4. On slopes of erosive soils, the granular blanket shall be 3 cm to 5 cm thick and be composed of granular aggregate material.

5. Granular aggregate shall be composed of clean, hard, durable uncoated particles.

6. Granular aggregate shall **not** be composed of mine waste, iron blast furnace slag, or blended nickel slag or clinkers due to the potential of ground water contamination from materials contained in the aggregate.

EROSION CONTROL STANDARD 7
CHEMICAL STABILIZATION

INTRODUCTION

Chemical stabilization refers to the use of chemical substances that change the properties of the soil surface, generally by aggregating the finer soil particles. Soil stabilizers, of a chemical nature, are used in place of temporary mulch materials and in combination with mulch materials to act as both a mulch tack and a soil blender.

APPLICATION

Chemical soil stabilizers are used for erosion protection of exposed soil slopes not subject to traffic during the temporary establishment of a seedbed. Chemical stabilizers can also be used to provide temporary erosion protection before re-vegetation is started. It is advantageous to use chemical soil stabilizers in areas where the use of vegetation as a soil stabilizer is not possible.

The liquids are generally applied to recently exposed soil to increase cohesion of the surface. This helps the development of a permanent vegetative cover by reducing erosion and retarding drying. Chemical soil stabilizers generally work best on a dry, highly permeable soil, or on soils already in place which are subject to sheet flow rather than concentrated flow.

Long-term protection is not achieved by chemical soil stabilizers. As a result, this method of stabilizing soils should be viewed as being only temporary. However, on light, sandy substrates, an improvement of the soil nutrient and water supply can be achieved through the use of hydrosillicates.

DESCRIPTION

A long lasting effect of up to two years can be obtained if the material is repeatedly sprayed, higher concentrations of the material are used, or if the granules are worked into the soil. However, re-vegetation of these areas may no longer be possible as the seeds may be prevented from germinating. In areas that suffer from frost, crust-forming stabilizers such as bitumen cannot be used as cracks develop and the surface breaks into pieces. Table 9 lists chemical soil stabilizers.

Table 9: Chemical Soil Stabilizers

Type	Characteristics
Alginate	Paste-like emulsion or granulate produced from sea algae and consisting largely of natural carbohydrates with associated mineral added.
Aquatain	Water dispersible, non-toxic.
Asphalt Sprays	Available as an asphalt emulsion or as a liquid asphalt.
Bitumen	Thick-flowing undilutable emulsion or a cold emulsion, 50% dilutable with water.
DCA-70	Water dispersible, non-toxic, non-phytotoxic.
Hydrosillicates Methylcellulose	Gel-like elastic film in a powder form or as a water based emulsion.
Plastic Emulsion	Usually a liquid which can be diluted with water, producing a thin film to cover the surface of the soil.
Polyvinyl Alcohol	An emulsion with water.

INSTALLATION

Application of the liquids is usually conducted with standard hydroseeding equipment or coarse pressure spraying nozzles. Asphalt sprays and rubber emulsions can be applied using non-air entraining equipment.

It is recommended that a representative plot be tested with the chemical soil stabilizers so that the correct mixture and application rate of chemicals and water can be selected.

MAINTENANCE

The period of effectiveness lasts from a few weeks to half a year. It will be longer where hydrosillicates are used and where granules are worked into the soil. Repetitive spraying will prolong the effect.

SPECIFICATIONS

All chemical soil stabilizers should be applied at the manufacturer's approved rates.

EROSION CONTROL STANDARD 8
NETS AND MATTING

INTRODUCTION

Nets and matting are placed on the ground surface to stabilize the soil. They may also be used in combination with mulch materials. Generally, nets and mats are inexpensive, easily placed and not subject to windblow providing they are properly anchored.

APPLICATION

Mats used without other stabilization techniques are suitable for use on level areas, in waterways, or on slopes. Primary use is on steep slopes and where newly established vegetation in swales and channels requires protection. Matting is used in areas where soil moisture is high, as soil moisture is not retained by the nets or mats. Mats can also be applied to areas where high velocity from runoff tends to scour newly established or establishing vegetation. When used in a combination with mulch materials, mats act as an anchor binding the mulch material and preventing windblow.

DESCRIPTION

Net and mat materials include jute, twisted paper mesh, fiberglass, cotton, finely woven plastics, excelsior and woven metal wire. Staples, usually made of plain iron wire, are used to hold the mats in place.

INSTALLATION

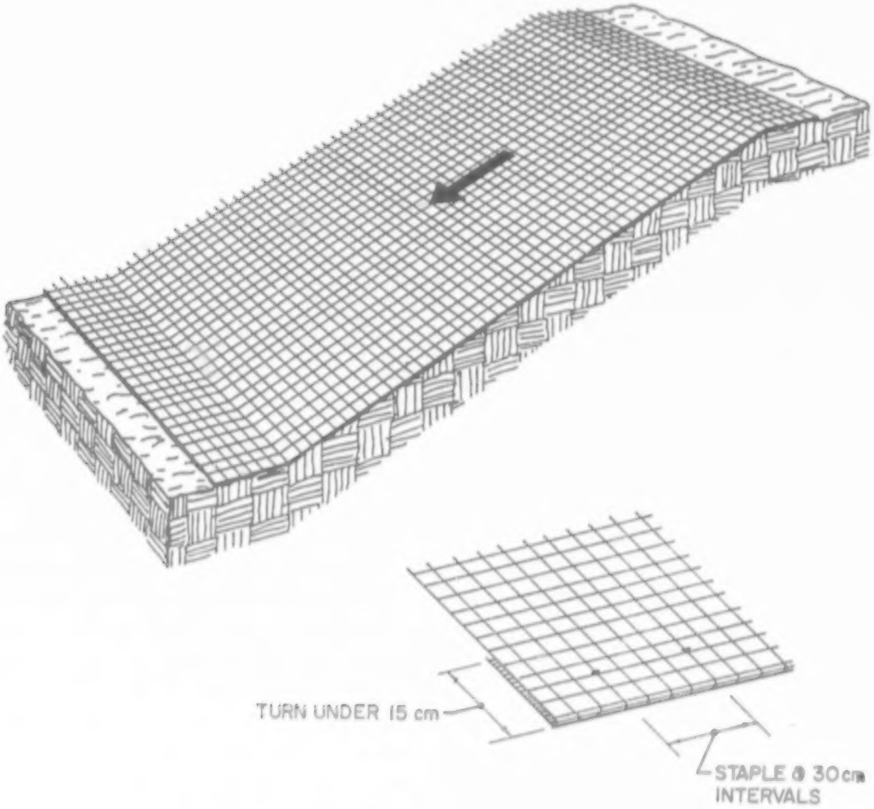
Obtaining a firm, continuous contact between the soil surface and the mat is the most important aspect to consider during installation. Failure to maintain contact renders the process useless and results in further erosion. The area that is to be protected should be shaped or graded to provide a good surface for mat placement. Material that prevents good contact between the mat and the soil surface, such as rocks or debris larger than 4.5 cm in diameter, must be removed.

The mat should be laid from the top of the slope and allowed to roll down the slope. It should be placed loosely over the soil. Stretching of the mat should be avoided. Refer to Figure 7.

When the mat has been stapled and the seed has been applied, the mat should be rolled to make certain there is good contact between the mat and the soil. See **Section D BMP Specification Details (Hillside Blanket Installation)**.

NOTE: If seeding is required, the site must be seeded before installation of the nets or mats, unless seed is imbedded directly in the nets or mats.

Figure 7: Netting and Matting



MAINTENANCE

The protected area should be regularly inspected, especially after a rainfall, to check for mat separation or breakage. If breakage does occur, any damage should be repaired immediately.

Temporary inspection should continue until the grasses have become well established. After a year, a top dressing of fertilizer may be applied to improve the vegetation covering and assist degradation of the temporary matting.

SPECIFICATIONS

1. In areas where the soil is highly erodible or when mulching is carried out in summer or late fall, mats shall only be used with an organic mulch.

2. Mats shall be installed over the mulch, except if the mulch is wood fiber. Wood fiber may be applied over the installed mat.

3. Excelsior matting may be used at all times of the year and may be applied alone on erodible soils, as they are considered to be protective mulches.

4. The ends of the mat shall be buried in a trench at least 15 cm deep, at the top of the slope. Earth shall be tamped over the anchor slot and staples shall be applied every 30 cm across the top and every 1 m along the mat edge.

5. The adjacent edges of two adjoining mats shall be overlapped 10 cm and stapled together.

6. Staples shall be applied at 1 m intervals down the center of the mat.

7. In areas where strips are to be joined, a new roll of mat shall be inserted into an anchor slot, in the same manner as the up-slope end. The end of the previous mat shall overlap the new mat by 50 cm and then it shall be turned under 15 cm.

8. Staples shall be applied every 30 cm across the end of the roll at the end of the turned-under mat, just below the trench or anchor slot.

9. At the bottom of the slope, the mat shall be led out to a level area before it is anchored and the ends turned under 15 cm. Staples shall be applied every 30 cm across the end.

10. Erosion check slots shall be made on areas that are highly erodible or where the slopes exceed 4H:1V. A fold of mat shall be inserted into a trench or anchor slot every 5 m and tamped firmly. Staples shall be applied every 1 m across the downstream portion of the mat.

11. Staples will be made of 4 mm diameter, or heavier, plain iron wire and will be at least 15 cm in length.

EROSION CONTROL STANDARD 9
TREES AND SHRUBS

INTRODUCTION

Trees and shrubs are forms of vegetation that can be used to cover and stabilize disturbed areas as well as to prevent the initiation of erosion. They form a canopy above the ground and thus protect the soil surface from the full impact of falling rain and high winds. When the stand is well established a layer of litter also covers the ground and, with decomposition, increases the soil absorption capacity. Trees, particularly evergreens, will slow down the melting of snow and runoff in the spring. The roots of shrubs and trees, however, are not as effective as grass roots in holding the topsoil against high velocity surface runoff.

Herbaceous vegetation provides erosion control more quickly. Time is needed to establish a good stand of woody species, during which competing herbaceous vegetation must be controlled.

Planting of very large woody stock is expensive and not necessarily effective sooner than planting of smaller and better-balanced stock. Hand planting of large and difficult areas can also be expensive. However, maintenance of established stands can also be expensive.

APPLICATION

Trees and shrubs may be used to protect graded or cleared areas from water and wind erosion where adequate topsoil is available and where a permanent vegetative cover other than herbaceous species is wanted. They are best used on steep or rocky slopes where mowing is not feasible, in shady areas where herbaceous species experience difficulty, and where forestry, landscaping and wildlife features are desired.

Trees and shrubs will help control foot traffic, will not require as much maintenance as mowed lawns, and will be more attractive than unmowed grass cover. However, these plants cannot prevent soil slippage on a soil that is not stable due to its texture, structure, water movement or excessive slope.

DESCRIPTION

Species Selection

A wide range of trees and shrubs can be grown in Alberta. While cost and availability are important, the choice of species should be based on a range of criteria including winter hardiness, tolerance to soil and air conditions, and suitability of planting.

In general, the choice of species narrows as the planting site becomes drier, less fertile and colder. Since erosion-prone soils are often dry and infertile as well as unstable, the site should be carefully inspected before the final section of species. Examples of such species include, but are not limited to: Alnus, Cornus, Elaeagnus, Hippophae, Salix, Sherpherdia, and many others. Though able to grow in soils poor in nitrogen, these plants exhibit various tolerances to other site factors such as climate, soil pH, soil moisture, root competition and shade.

Species with the ability to spread over large areas by suckering may or may not be desirable. These types of species would include the genera Caragena, Cotoneaster, Cornus, Elaeagnus, Populus (Aspen section), Rosa, Salix, Spirea, and Symphoricarpos.

Most deciduous species that are not nitrogen-fixing are rather demanding in site requirements. For best growth they require a deep, uneroded, fertile, moist but well-drained soil. Coniferous species such as spruce (Picea) are more adaptable to areas of dry, exposed slopes or shallow topsoil. Grasses and shrubs are more adaptable to dry slopes while spruce in best utilized on shaded, cooler slopes.

In general, species that are native to the area can be expected to be winter hardy. Winter hardiness zones, based mainly on minimum water temperatures, have been published for many species that are available in Alberta. These zones can be used as a guide when selecting among exotic species. Table 10 lists native trees and shrubs that are suitable to Calgary's climate.

Table 10: Native Trees and Shrubs

Latin name	**Common name**	**Moisture Regime**				**Notes**
		Aquatic	**Emergent**	**Hydric-mesic upland**	**Mesic-xeric upland**	
Trees and shrubs						
Alnus crispa	green alder			•		
Amelanchier alnifolia	saskatoon				•	
Betula occidentalis	water birch, black birch		•	•		
Cornus stolonifera	red osier dogwood			•	•	
Elaeagnus commutata	silver-berry; wolf willow				•	
Juniperus communis	common juniper				•	
Juniperus horizontalis	horizontal juniper				•	
Picea glauca	white spruce			•	•	
Populus tremuloides	trembling aspen			•	•	
Populus balsamifera	balsam poplar			•	•	
Potentilla fruticosa	shrubby cinquefoil				•	
Prunus virginiana	western chokecherry				•	
Pseudotsuga menziesii	douglas fir				•	
Ribes aureum	golden currant			•	•	
Ribes lacustre	bristly black currant			•	•	
Ribes oxyacanthoides	wild gooseberry				•	
Rosa acicularis	prickly rose			•	•	

Latin name	Common name	Moisture Regime				Notes
		Aquatic	Emergent	Hydric-mesic upland	Mesic-xeric upland	
Rosa arkansana	prairie rose			•	•	
Rosa woodsii	common wild rose			•	•	
Rubus idaeus	wild red raspberry			•	•	
Salix amygdaloides	peach-leaved willow			•		
Salix bebbiana	beaked willow			•	•	
Salix discolor	pussywillow; diamond willow			•		
Salix exigua	sandbar willow			•		
Salix glauca	smooth willow			•		
Salix lutea	yellow willow			•	•	
Sambucus racemosa	elderberry			•		
Shepherdia argentea	silver/thorny buffaloberry			•	•	
Shepherdia canadensis	canada buffaloberry				•	
Spiraea betulifolia	white meadowsweet			•		
Symphoricarpos albus	snowberry			•	•	
Symphoricarpos occidentalis	buckbrush/wolfberry			•	•	
Viburnum edule	low bush cranberry			•	•	
Viburnum opulus	high bush cranberry			•	•	

Planting Stock

The success of any planting will also largely depend on the quality and suitability of the planting stock. Good stock should be sturdy and have a well-branched root system.

When planting larger areas, it is usually best to use young plants grown in the nursery for only a few years. Young plants include rooted cuttings, seedlings (plants grown for 1 to 3 years from seed), transplants (seedlings that have been transplanted once) or small trees and shrubs 1 to 3 m tall.

Larger stock for landscaping purposes may sometimes be needed, but this is more expensive and must be well cared for during the first few years. The best survival and growth will be shown by young stock that is relatively large for its age.

Seedlings and transplants are normally purchased bare-root (where soil is not kept around the roots) and the plant must be moved while the buds are completely inactive.

However, trees 1 to 2 m in height should have soil kept around the roots in a root ball, either tied around with burlap (as balled and burlapped stock) or in a fiber or plastic pot (as containerized stock). Some species may be established by the use of unrooted cuttings or by root cuttings (Populus,Salix).

A wider range of trees and shrubs are available from commercial nurseries. Wild plants may also be dug carefully and replanted on the property but this may be risky. Root pruning one or two years before digging may help encourage the growth of new roots. Small, shallow rooted deciduous trees growing in a clay loam soil are most easily transplanted.

INSTALLATION

Site Preparation

Site Preparation is essential for planting most deciduous species. It may be in the form of complete or partial cultivation or chemical eradication of competing vegetation.

Ploughing and tilling of the total plantation area the year before planting is the best method of site preparation. However, in erodible soils, strips up to 2 m wide may be ploughed along the contour and the trees planted in the overturned soil. In erodible soils, trees are typically planted by hand. Chemical site preparation either before or after planting can be used in place of mechanical site preparation on stony, hilly or other areas not suited to ploughing and cultivation. Small areas can be prepared by hand scalping the sod with a shovel.

Very poor and sandy soils ma not grow a very thick stand of herbaceous weeds. Site preparation is not necessary on such sites and appropriate woody species can be planted directly into the sod. Soil amendments and fertilizer can be applied at rates suggested by a soil test. Approval from Park Development & Operations is required for soil amendments and fertilizer requirements in ER and natural areas.

Planting

The best time to plant is in early spring, as soon as possible after frost leaves the ground. Planting in the fall is more risky as the plants may be heaved by frost if the roots are not established. However, it may be more convenient to fall plant deciduous species that flush very early in spring. Planting should be done when the plants are dormant.

Trees should be planted from 1.5 to 3 m apart. Shrubs may be planted at a spacing of 0.5 to 1.5 m. Spacing for native or wild plant material should be the same or similar to the existing conditions that are being replicated.

Small Stock

Planting stock under 1 m in height is usually planted by hand on steep or stony sites or on areas needing fewer than 4000 trees. Hand planting involves making a hole with a hand shovel, placing the tree in the hole so that the roots are well extended below ground level with the stem upright above ground level, and packing the soil back firmly around the roots with the heel. Water as required to ensure plants do not dry out.

When larger numbers of plants are needed and gradients are accessible, a tractor-drawn planting machine with a two or three man crew can be used. The machine cuts a trench or ploughs a furrow for the tree, and firms the soil back around it with packing wheels. Machine planting is faster than hand planting, but care still needs to be taken to ensure that trees are inserted upright at the correct level, with roots well spread out.

If no planting machine is available, a furrow may be ploughed with standard agricultural equipment. Trees can then be planted and soil packed back around the roots manually. Plants should be planted with topsoil around the roots rather than with roots going directly into the subsoil.

Larger Stock

Plants 1 to 2 m tall are usually planted by hand. A motorized post-hole digger, either hand-carried or tractor mounted, can be used on relatively stone-free sites to reduce the amount of hand digging. A backhoe is helpful for planting the largest stock.

Whenever possible, topsoil mixed with better quality subsoil should be used in the planting hole. If topsoil is unavailable, the subsoil can be improved by mixing in 1/3 by volume of peat moss, composted manure, cocoa shells or well-rotted sawdust. About 0.03 kg of a complete fertilizer such as 10–10–10 N-P-K per plant should then be added to the mixture going into the planting hole. Final depth of planting should be close to the original depth of the plant.

With containerized stock, containers must be removed completely before planting. For balled and burlapped stock, any rope around the trunk is cut and removed after the tree has been placed in the hole. The burlap should be loosened and removed if practical, without breaking the soil of the root ball. After the hole is half-filled with soil, the soil should be packed firmly around the root ball. Water should be added to settle the soil and eliminate air pockets. When the water has drained off, the remainder of the hole can be filled and the soil packed as before. Extra soil can be used to form a shallow basin around the tree for holding irrigation water.

Any corrective pruning should be done at the nursery prior to transportation to the planting site. If roots are broken or damaged, the tops of deciduous trees may be cut back to balance the root system. The leader on evergreens should remain untouched.

Where practical, steep slopes should be covered with a protective mulch such as wood chips or straw to conserve moisture and control erosion. If fresh organic matter is used as a mulch, a slow release fertilizer (or an organic form) should be added as well.

A temporary cover crop of non-competitive annuals can be used as an alternative erosion control (but not with small woody seedlings) until planted materials offer protective cover. Where erosion hazard is very high, heavy jute netting or landscape mats of excelsior or fiberglass can be pegged to the slope.

MAINTENANCE

Staking on the side of the plant is necessary for trees over 1 m tall to prevent excessive swaying. A wooden or metal stake is driven firmly into the ground close to the tree and attached to the trunk by a commercial tie or a length of wire passed through a piece of rubber hose. Ideally, young trees should receive about 2.5 cm of water each week for the first two years after planting. When rain does not supply this need, the trees should be watered deeply but not more than once per week. This is essential for larger stock in the first year.

On good soils, weed control is more important than fertilization for small trees and shrubs because fertilized weeds may suppress the newly planted material through root competition or by faster growth. Weeds must be controlled by either careful cultivation, herbicides or mulching around the tree for the first few years after planting. Poor soils can be fertilized according to soil test results.

Girdling by mice and browsing by ground squirrels and rabbits can cause heavy damage, particularly in deciduous plantations near grassy areas, old windrows, young evergreen plantations or natural cedar stands. Many shrubs are able to recover by sprouting more stems. Trees can be protected by wrapping the trunk with a commercial metal or plastic tree guard from ground level up to a height of 1 m.

Staked trees should be checked before winter for two years to make sure the ties and wire are still secure. After two or three years, ties and stakes should be removed. Tree guards should also be checked in the fall to make sure they remain in place without damaging the trunk.

Health and survival of plants should be checked the first fall or the following spring. If the survival rate is low, dead plants can be replaced by replanting. As trees grow older, little maintenance is needed. Some corrective pruning may be necessary, depending on the objectives of the planting. Limbs should be removed to avoid weak, narrow-angle crotches. Some thinning out of shrub stems may be helpful in rejuvenation and attaining a good form of growth. Damaged or dead wood should always be removed.

Trees over 15 years old may need to be thinned or spaced if there is no natural dying off of the weaker specimens.

Plantations that are too thick will stagnate in growth and the health of individual trees will be weakened. Thinning will also promote the development of a soil-protecting understorey that would not occur in dense shade.

SPECIFICATIONS

Planting Stock

1. Nursery stock shall be true to name, and of the size or grade stated. Sufficient labels or markings shall be used.

2. Nomenclature used shall conform to the latest rules of International Code of Nomenclature for Cultivated Plants.

3. Quality shall be normal for the species when grown under proper cultural practices. All nursery stock shall be viable, substantially free from pests and disease, and undamaged. Roots shall not be subject to long exposure to drying winds, sun or frost, between digging and delivery. Root balls shall be free from pernicious weeds such as crabgrass, horsetail and bindweed.

4. Packing or wrapping shall be adequate for the protection of the stock and sufficient to prevent heating or drying out during storage and transportation.

5. All normal quality nursery stock shall have an adequate fibrous root system cleanly cut at the ends. Split roots are not acceptable. Pertinent facts, such as when larger stock was transplanted or roots pruned, should be available.

6. Material dug from native stands or woodlots shall be designated as "collected". Locally sourced material should be appropriate to the site conditions.

Handling

1. Plants must be protected at all times from exposure to sun and drying winds by keeping the roots covered with moist material. Plants shall be shaded at all times between digging and planting.

2. Plants should be packed and tied tightly to prevent them from moving about and being damaged during transport.

3. Balled material must not be set on a concrete floor since earth balls will give off excessive moisture to the concrete and the roots will be damaged. Burlap balls should be laid on a sheet of polyethylene.

4. Plant material shall be handled as living material and not tossed around carelessly.

5. The time between digging and replanting shall be reduced to a minimum.

6. Plants that cannot be planted quickly shall be heeled in by placing the roots in a trench, inclining the stems at an angle of 45 degrees or lower and covering the roots with soil. The soil covering the roots must be kept wet.

EROSION CONTROL STANDARD 10
GRASSED WATERWAYS

INTRODUCTION

Grassed waterways are broad and shallow channels, stabilized by suitable herbaceous vegetation, that are designed and constructed to carry concentrated flows of surface water across land to a drainage outlet. The purpose is to convey runoff without causing erosion damage. The flow is retarded by the shallow grade, the wide channel and the vegetation growing in it. With favorable soil conditions grassed waterways can generally handle water velocities up to 1.8 m/s. See Table 11 for maximum velocities and channel slope.

APPLICATION

Grassed waterways may be used where added channel capacity or stabilization is required to control erosion resulting from concentrated runoff. They should be used where channels of the proper grade can be constructed, vegetated and maintained to achieve the required control. They are often constructed in natural draws across farm fields where water naturally collects and flows to an outlet.

Table 11: Permissible Velocities in Earth and Grass-Lined Channels

Earth Linings

Soil Types	**Permissible Velocities**	
	(m/s)	**(ft/s)**
Fine Sand (noncolloidal)	0.8	2.5
Sandy Loam (noncolloidal)	0.8	2.5
Silt Loam (noncolloidal)	0.9	3.0
Ordinary Firm Loam	1.1	3.5
Fine Gravel	1.5	5.0
Stiff Clay (very colloidal)	1.5	5.0
Graded Loam to Cobbles (noncolloidal)	1.5	5.0
Graded Silt to Cobbles (colloidal)	1.7	5.5
Alluvial Silts (noncolloidal)	1.1	3.5
Alluvial Silts (colloidal)	1.5	5.0
Coarse Gravel (noncolloidal)	1.8	6.0
Cobbles and Shingles	1.7	5.5
Shales and Hard Pans	1.8	6.0

Grass Linings

Channel Slope	Grass Types	Permissible Velocities	
		(m/s)	(ft/s)
0.5%	Reed canarygrass** Tall fescue Kentucky bluegrass	1.5	5.0
	Grass-legume mixture	1.2	4.0
	Red fescue Redtop Small grains (temporary)	0.8	2.5
	Streambank western wheatgrass Slender wheatgrass Fowl bluegrass Hair grass	unknown	unknown
5-10%	Reed canarygrass** Tall fescue Kentucky bluegrass	1.2	4.0
	Grass-legume mixture	0.9	3.0
Greater than 10%	Reed canarygrass** Tall fescue Kentucky bluegrass	0.9	3.0

* For highly erodible soils, decrease permissible velocities by 25%

** Potentially invasive species; obtain approval from Park Development & Operations for applications on public land

DESCRIPTION

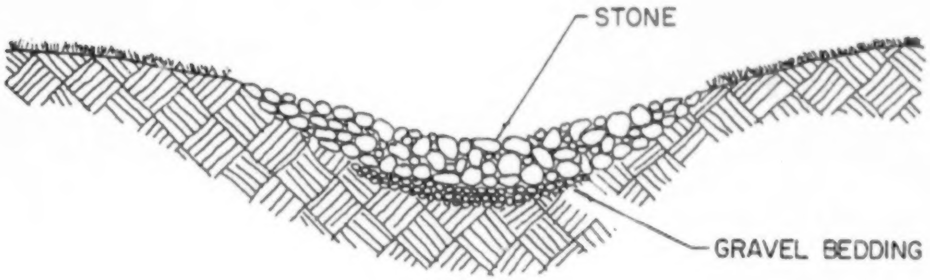
Grassed waterways are generally parabolic in cross section but can also be trapezoidal. They should be nearly flat bottomed. Constructing the waterway too deep, too narrow or v-shaped may lead to gully formation. Waterways can be designed to accommodate various grades. Ideally, the slope of the channel bottom should be about 1% (1 m fall per 100 m of channel length). Slopes of grassed waterways should also be about 1%. Grassed waterways should be constructed with shallow grades to conduct the water slowly across the land. The herbaceous vegetation in the channel retards the flows and resists the soil-eroding action of the water. Each waterway should have a stable outlet that must discharges without causing erosion.

Subsurface drainage should be provided for sites having high water table or seepage problems. A drainage tile (weeping tile or french drain) beneath the grassed waterway will drain residual water, providing a channel that dries quickly after both spring runoff and summer storms.

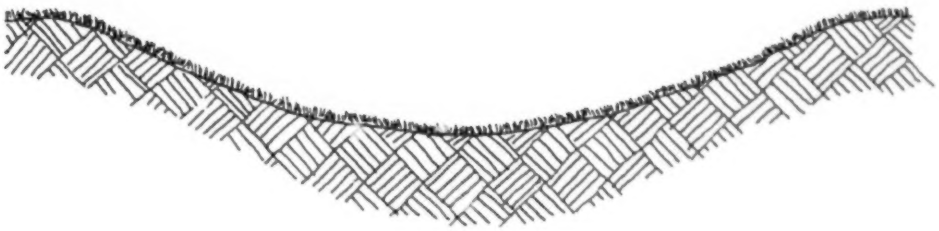
Drainage tile beneath a waterway can also be sized to take part of the channel flow, thus reducing the required capacity and size of the waterway. Water can be allowed to enter tile catch basins intercepting the channel flow at critical points along the waterway.

The cost of a drainage tile installation for this purpose must be weighed against the accommodation of a wider channel. To some extent, a stone center is an alternative to a subsurface drain (see Figure 8).

Figure 8: Grassed Waterways



WITH STONE CENTRE



WITHOUT STONE CENTRE

INSTALLATION

The outlet should be constructed and stabilized prior to operation of the waterway. Two basic outlets at a ditch are a rock chute spillway and a drop inlet back from the ditch bank.

Late spring and summer are good times for construction of a grassed waterway as the soil can generally be easily worked and grass seed will catch easily. A dry period must be chosen for poorly drained areas. All stones, stumps and obstructions should be removed from the path the waterway will follow. The path itself should be staked for construction.

It is preferable to use grading equipment to excavate or shape to line, grade and cross section as required to meet criteria. A plough can be used to throw furrows toward the center if the proposed waterway is gullied.

The waterway should be free of bank projections or other irregularities, which will impede normal flow. The entire channel should be smoothed and compacted to prevent unequal settlement. Topsoil should be stockpiled and re-spread where necessary to provide a good seed bed. Adequate fertilizer must be applied for grass establishment.

One mixture currently recommended for seeding in grassed waterways includes bird's-foot trefoil at 12 kg/ha and creeping red fescue at 20 kg/ha. Other possible species include brome grass, Kentucky bluegrass and white Dutch clover. Reed canarygrass survives poor drainage conditions but may clog the channel, causing sediment deposition.

Immediate protection in critical areas can be provided by sodding. However, a mulch may be used to protect the waterway until the vegetation becomes established. Refer to **Erosion Control Standards 1 and 4 for Seeding and Sodding**.

MAINTENANCE

Regular maintenance is important to keep a waterway in good working condition. Bare or eroded spots should be quickly sodded or reseeded. Fertilizing and mowing or spraying for weed control should be done frequently enough to keep the vegetation in vigorous condition.

Hay may be harvested. Grazing is permitted for short periods of time only, but not during wet conditions. Grassed waterways should not be used as travel lanes either for cattle or machinery in order to prevent the development of gullies.

SPECIFICATIONS

The design of grassed waterways depends greatly on:

a) Water flow (m^3/s)
b) Velocity (m/s)
c) Slope grade (%)
d) Type and maintenance of vegetation and soil

Detailed tables are available for calculating the top width and the depth of a parabolic waterway from the above information. Top width increases directly with water flow and grade but decreases with increased velocity. Channel depth does not change much with water flow but decreases with increased velocity and decreases with increased grade.

1. The waterway outlet shall be constructed and stabilized first.

2. The grassed channel shall not be less than 5 m in width or less than 0.15 m in depth.

3. The design water surface elevation of the waterway should be equal to or less than the design water surface elevation of diversions or other tributary channels contributing water flow.

4. The side slopes shall rise no more than 1 m vertically to 4 m horizontally (4H:1V). Flatter side slopes will permit easier crossing of the channel by machinery and are preferable. 4H:1V side slopes allow for tractor mowing along the slope.

5. To control meandering low flows, the top width of parabolic waterways should not exceed 9 m and the bottom width of trapezoidal waterways should not exceed 4.5 m unless multiple or divided waterways, stone center, or other means are provided.

6. The entire channel should be smoothed and compacted to prevent unequal settlement.

7. The site should be prepared according to **Erosion Control Standards 1 and 4 for Seeding and Sodding**.

8. If seeding is done, it should be carried out with a suitable seed mixture within 24 hours after construction on the freshly worked, moist soil.

EROSION CONTROL STANDARD 11
STORMWATER CHANNELS AND DITCHES

Stormwater channels are watercourses designed to safely convey excess stormwater runoff from the developing area. These channels shaped and lined with vegetation or structural material will ensure that the concentrated surface runoffs from the site will be conveyed without causing any erosion or sedimentation. See **Section D BMP Specification Details.** The minimum design criterion for the drainage ditches should be at least the peak flow from the 2-year return period storm. In cases where flooding and the resulting damage could be severe, the capacity of the channel should be further increased.

The design of the channel should be such that the flow velocity expected from the selected design frequency storm shall not exceed the permissible velocity for the soil or types of grass used. Refer to **Erosion Control Standard 10 Grassed Waterways**, Table 11.

Open ditches have the advantages that they are usually less expensive than other types of drains, and inspection is easy. The disadvantage of open ditches is that the maintenance costs usually exceed the cost of other types of installations. Construction specifications require that:

i) All trees, brush, stumps, roots, obstructions and other unsuitable material shall be removed and properly disposed of.
ii) The final channel should have the proper grade and shape of the cross section in order to discharge the design flow.
iii) Where fill is used to construct the waterway, fills shall be compacted to prevent unequal settlement that could cause damage in the waterway.
iv) Stabilization, if required, shall be done as specified under vegetative practices. (Sodding is recommended.)

EROSION CONTROL STANDARD 12
CONSTRUCTION ROADS AND PARKING AREAS

Temporary stabilization of construction roads and parking areas with stone immediately after grading will reduce the amount of erosion and sedimentation.

Temporary roads should follow the contour of the natural terrain. Temporary parking during the construction activity should be located on flat areas where possible, and grades should be sufficient to provide drainage. Immediately after grading is completed, a 15 cm to 20 cm course of aggregate should be applied. Filter fabric may be used to provide additional stability. The temporary roads and parking areas may require periodic maintenance by providing gravel. Roadside ditches and adjacent cut or fill areas should be stabilized with temporary or permanent vegetation.

EROSION CONTROL STANDARD 13
DUST CONTROL

Soil erosion by wind can be a significant problem. Dust control prevents wind transport of dust from disturbed soil surfaces onto roadways, drainage ways and into watercourses.

Dust can be controlled by:

- Clearing vegetation only from areas that will be worked right away.
- Vegetating or applying mulch to areas that won't receive vehicle traffic.
- Constructing wind breaks or wind screens.
- Sprinkling the site with water until the surface is wet. Care should be taken that this does not lead to tracking of mud onto nearby streets.
- Spraying exposed soil areas with a dust palliative. Used oil is prohibited as a dust suppressant.
- Stopping work in serious adverse wind conditions.
- Using and maintaining internal haul roads.

To protect adjacent roads and property owners:

- Lower speed limits to decrease dust stirred up from unpaved roads and lots.
- Add surface gravel to reduce the source of dust emission. The amount of fine particles should be limited to 10 to 20%.
- Use geotextiles to increase the strength of new roads or roads undergoing reconstruction.
- Encourage use of alternate paved routes if possible.
- Encourage use of internal haul roads and maintain as required.
- Restrict use by tracked vehicles and heavy trucks to prevent damage to the road surface and base.
- Apply chemical dust suppressants.
- Pave unpaved permanent roads.
- Stop work in serious adverse wind conditions.

SECTION C

BMP STANDARDS AND SPECIFICATIONS FOR SEDIMENT CONTROL MEASURES

SEDIMENT CONTROL MEASURE 1
VEGETATIVE BUFFER STRIP

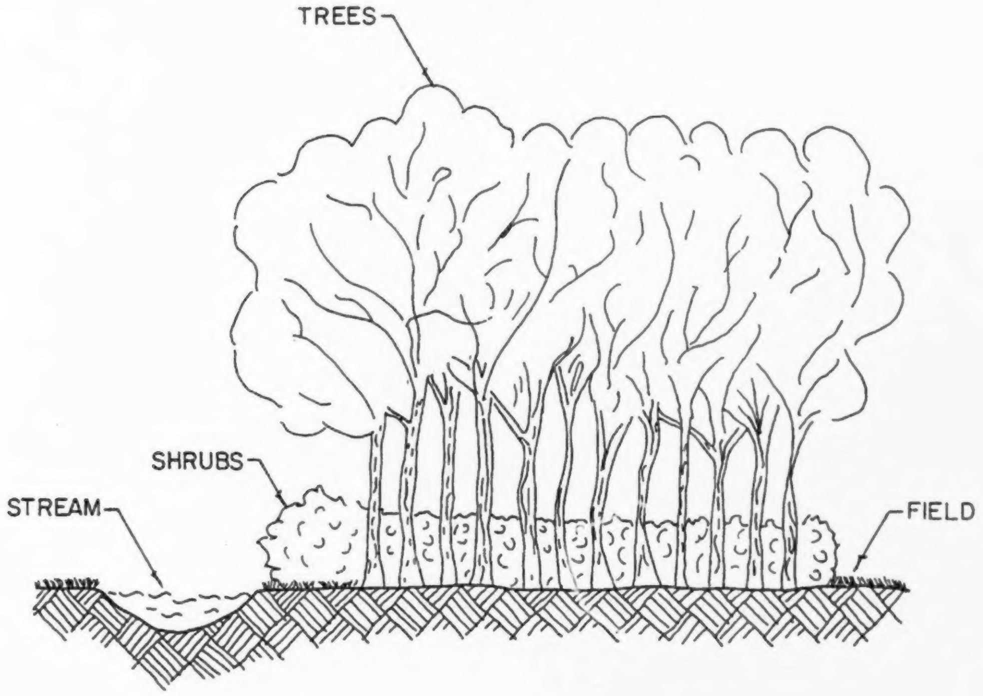
INTRODUCTION

Vegetative buffer strip refers to a strip of dense vegetation that is used to prevent sedimentation or erosion by inter-position between disturbed and sensitive areas. Sediment, organic matter and other pollutants are removed from runoff by filtration and absorption. A strip of trees or shrubs can also serve as a windbreak to reduce wind erosion and soil desiccation.

APPLICATION

Vegetative buffer strips may be used to protect property boundaries, steep slopes, surface water features, and other areas sensitive to sediment accumulation (see Figure 9). Buffer strips may be planted or seeded. Where possible, vegetation that occurs naturally can be retained. Planted or seeded vegetation strips generally require a substantial time before becoming effective.

Figure 9: Vegetative Buffer Strip



TREED BUFFER STRIP IS TO BE AS WIDE AS IT IS HIGH. APPROXIMATELY 20 METRES.

DESCRIPTION

Buffer strips are generally densely vegetated, easily maintained bands of growing plants. They may consist of grasses, broad-leaved herbaceous plants (forbs), vines, shrubs and trees. Buffer strips are oriented perpendicular to the anticipated direction of sediment flow.

Trees and shrubs take longer to establish than grasses or forbs. However, once established, they require little maintenance and have deep and extensive root systems combined with a relatively high protective canopy.

Trees and tall shrubs are most effective for windbreaks. However for maximum slowing of surface runoff and collection of sediment, a complete mat of vegetation at ground level is important. This is best achieved by grasses, herbaceous legumes, vines and low shrubs which grow well in shady areas.

Grass or mixed grass/forb strips provide the thickest mat of vegetation at ground level. Such buffers do not need to take up as much space as strips containing trees and shrubs.

INSTALLATION

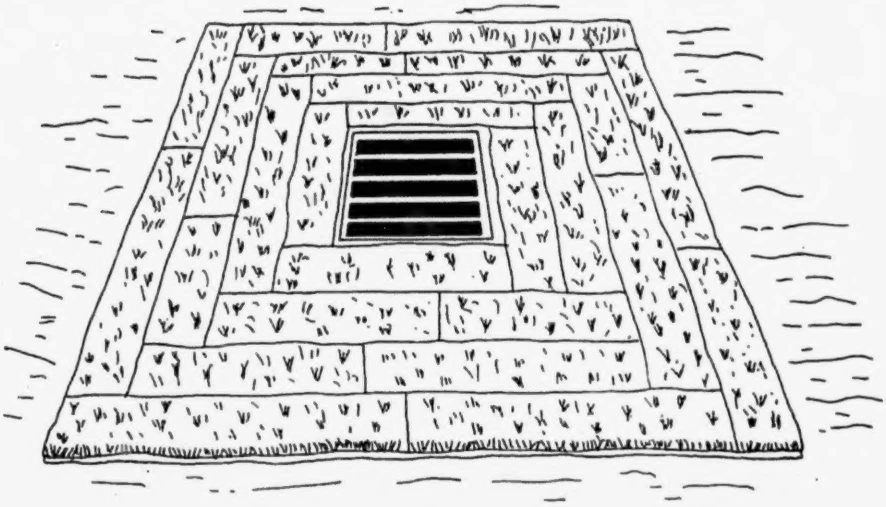
Existing narrow vegetative strips and fence lines, near streams and on top of slopes should be maintained. They may be widened by simply stopping cultivation and herbicide spraying of the areas. Natural regeneration will occur but there will be little control over species composition.

Artificial establishment of vegetation is needed in areas where the vegetation has been removed or where the existing buffer is not adequate. Eroded or steep slopes may be graded, carefully conserving the available topsoil.

Seeding a mixture of grasses and herbaceous legumes in unvegetated areas is an inexpensive method of stabilizing soil, particularly if the area is flat to moderately sloping. Sodding results in faster establishment of turf but is more expensive. Field sod, not certified as to composition, may be used where the degree of weed infestation will not be crucial. More information is provided in **Erosion Control Standards 1 and 4 Seeding and Sodding**.

When sodding, the strips of sod should be oriented at right angles to the slope (to the flow of water). Drain inlets should be completely surrounded (see Figure 10). Trees and shrubs can be established in conventional ways. Since it will take time for them to become effective, it may be necessary to provide a complete cover of mulch (such as wood chips) or temporary grass cover on slopes, until the woody plants become established and grow to a complete protective cover.

Figure 10: Sod Filter (Vegetative Strip)



FOUR STANDARD STRIPS OF SOD ON EACH SIDE OF THE DROP INLET

Where it is not practical to grade a very steep slope, terraces can be built, providing horizontal steps in which to plant vegetation. Alternatively, the slope can be broken up by the addition of "contour wattles". These are bundles of live willow cuttings which are anchored with live willow stakes in trenches along the slope face. They act as a base vegetation growth and as a strap to slow surface runoff. The willow stakes and cuttings are capable of rotting if there is sufficient moisture.

On streambanks, fascine rolls (bundles of willow cuttings filled with coarse gravel and wired tightly) can be set against the bank so that the parts that are to take root touch the ground above water level and are able to get sufficient moisture. Covering with earth improves the contact with the ground and slows the loss of moisture from the wood. Various combinations of parked fascines and willow mattresses can be used for different streambank conditions. Woody plants can also be planted in the crevices of stone facing.

MAINTENANCE

Maintenance of vegetative buffer strips will vary with the intensity of usage as well as the intensity of the natural forces working on them. Steep slopes are always susceptible to erosion when parts of the vegetative cover fails. Restabilization, regrading and replanting may be necessary on occasions. Streambanks are always vulnerable to new damage and should be checked after high water events. Gaps in the plant cover shall be filled with new plants and protected if necessary. The perpetuation of a good mat of ground vegetation will be important.

Erosion and soil compaction are frequently caused by cattle grazing the vegetation in the strip. Buffer strips must be protected by fencing where required.

SPECIFICATIONS

1. Existing natural vegetation shall be retained whenever possible.
2. A mat of vegetation and/or litter shall cover the ground at all times.
3. The vegetative strip shall be located perpendicular to the flow of water (or wind) to be filtered.
4. The minimum width for grass (sod) filter shall be 1.5m.
5. A treed buffer strip should be at least as wide as it is tall, about 20 m for effective self-support and maintenance of filtering abilities.
6. The minimum width for a buffer strip shall increase with increasingly erodible and difficult conditions.
7. Further specifications will be found in **Erosion Control Standards 1, 4 and 9 Seeding, Sodding, and Trees and Shrubs**.

SEDIMENT CONTROL MEASURE 2
ROCK FILTERS AND BRUSH BARRIERS

INTRODUCTION

Filters remove sediment and reduce the velocity of flowing water. They can be constructed from any stabilized porous material such as crushed rock. There is no predetermined shape for filters. However, it is important that runoff flow through the filter rather than around it.

Brush barriers can also be used as temporary filters. They impede surface runoff and stop the movement of sediment. Brush barriers are constructed by piling brush, stone and root mates into a mounded row. During clearing operations, a mixture of tree limbs, small vegetation, roots and small amounts of soil and rock can be made into windrows along the toe of a slope.

APPLICATION

Filters are used around drain inlets, along the toes of slopes, on small slopes, on sediment basin dams, between water bodies and next to downhill adjacent properties. They are used below disturbed areas subject to erosion. They should not be constructed in live streams or in swales where there is the possibility of a washout. Thus, they require an existing drainage system and are for relatively small drainage areas only.

Brush barriers are often constructed at the perimeter of a disturbed slope area, parallel to the contours. They are also used in small channels to prevent gully erosion during the site construction period.

DESCRIPTION

Filters may take the form of small dams and barriers. They may be linear or they may completely surround the location being protected (i.e. drain inlets).

Filters using rock as a filtering medium have a long useful life. However, their construction and repair may not be as simple, considering that rocks will not have the same consistent shape and will not hold together as well.

There is no predetermined shape for filters. They may, for example, surround storm drain inlets. Water must be forced to go through the filter and should never flow around it.

Brush barriers can generally be constructed from clean organic material made available from site clearing operations that is usually discarded. The filtration ability of the barrier is enhanced if a filter fabric is anchored over it.

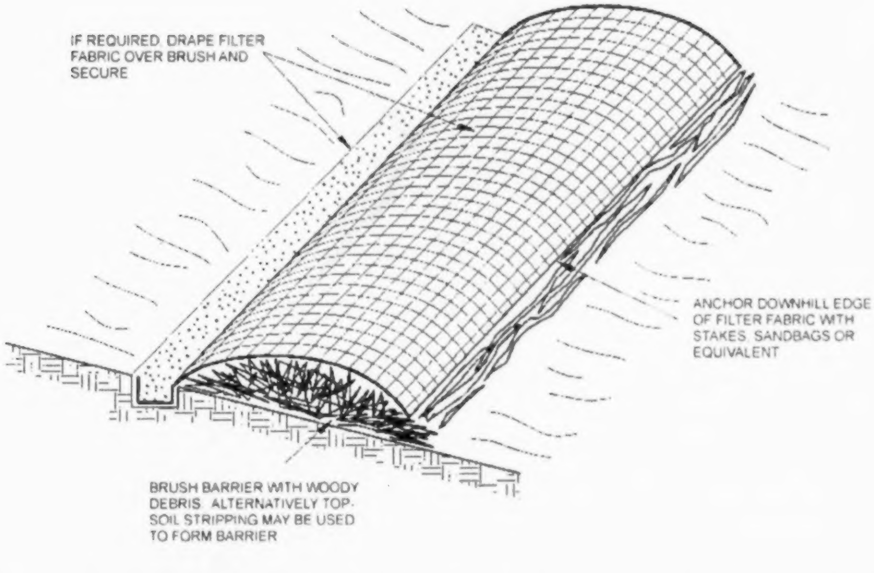
INSTALLATION

Rock or gravel filters can be constructed by placing concrete building blocks on the inside to keep stones from being washed away. Rock filters can also be constructed in a form similar to check dams (see **Sediment Control Measure 3 Check Dams**) for drainage areas up to 4 ha.

Brush Barrier

The size of a brush barrier will vary depending upon the amount of material available and the condition of the site. The barrier shall be constructed by piling brush, stone and root material into a mounded row on the contour. During clearing and grubbing operations, equipment can push or dump the mixture of limbs, small vegetation and root material, along with minor amounts of soil and rock, into windrows along the toe of a slope where erosion and runoff are expected. See Figure 11.

Figure 11: Brush Barrier


IF REQUIRED, DRAPE FILTER FABRIC OVER BRUSH AND SECURE
ANCHOR DOWNHILL EDGE OF FILTER FABRIC WITH STAKES, SANDBAGS OR EQUIVALENT
BRUSH BARRIER WITH WOODY DEBRIS. ALTERNATIVELY TOP-SOIL STRIPPING MAY BE USED TO FORM BARRIER

If a filter fabric is used, it is laid across the barrier with edges overlapping and secured by stakes in a trench immediately uphill from the barrier. The trench is then backfilled, and soil compacted over the filter fabric. The fabric is also anchored with twine to stakes on the downhill edge of the barrier.

MAINTENANCE

Filters shall be inspected after each rainfall. Close attention shall be paid to the prompt repair of damage, undercutting, end runs and erosion of the filter.

Sediment deposits must be removed when the level of deposition reaches about one half the height of the filter, and preferably sooner.

Temporary filters shall be removed when they have served their purpose, but not before the areas up the slope have been cleaned up, and permanently stabilized. Any sediment deposits shall be graded, prepared and seeded.

SPECIFICATIONS

Rock Filter

1. Aggregate for rock filters shall be composed of clean, hard, durable mineral particles free from organic matter, clay balls, soft particles or other substances that would interfere with their free-draining properties. Not more than 15%, by weight, shall be flat, elongated particles. Aggregates may be accepted or rejected on past field performance. Smaller size gravel will need to be supported by concrete building blocks.

2. In channel flow applications, the center of the rock filter shall be about 15 cm lower than the outer edges.

Brush Barrier

1. The material in the brush barrier shall be piled as thickly as possible, with no large openings or sharp projections.

2. The height of a brush barrier shall be a minimum of 1 m. The width of a brush barrier shall be a minimum of 1.5 m at its base.

If filter fabric is used:

3. Filter fabric must have adequate strength for porosity and filtering capability. The pores should be relatively large to prevent excessive siltation and impoundment of large quantities of water.

4. The filter fabric shall be cut into lengths sufficient to lay across the barrier from its upslope base to just beyond its peak.

5. A trench shall be excavated 15cm wide and 10cm deep immediately uphill from the barrier and along its length.

6. The filter fabric shall be draped across the width of the barrier with the uphill edge placed in the trench, and the edges of adjacent places overlapping each other.

7. The filter fabric shall be secured in the trench with stakes set about 1m apart.

8. The trench shall be backfilled and soil compacted over the filter fabric.

9. Stakes shall be set into the ground along the downhill edge of the brush barrier, and the fabric anchored by tying twine from the fabric to the stakes.

Note: Filter fabric is NOT recommended for brush barriers in channels.

SEDIMENT CONTROL MEASURE 3
CHECK DAMS

INTRODUCTION

Check dams are used to prevent channel erosion by reducing water velocities, lengthening detention times and increasing stream cross-sections. The structures can be made of straw, straw/silt fence, rock or rock gabions, wood or other durable materials, depending upon site conditions. Straw bale check dams can be susceptible to washouts and are not recommended where there is a potential for heavy channel flow.

Check dams are usually constructed across the channel, perpendicular to the contours. Poorly designed, installed or maintained check dams can create far more serious problems than those they were intended to prevent.

APPLICATION

Check dams are used where the capability of the earth or vegetative measures are exceeded in the safe handling of water at permissible velocities, where excessive slope conditions occur, or where water is to be lowered from one elevation to another.

DESCRIPTION

Log check dams can be economical in terms of material costs when logs are salvaged from clearing operations. However, log check dams require more time and labour to install. Stone for check dams must generally be purchased, but the cost is offset by the ease of installation.

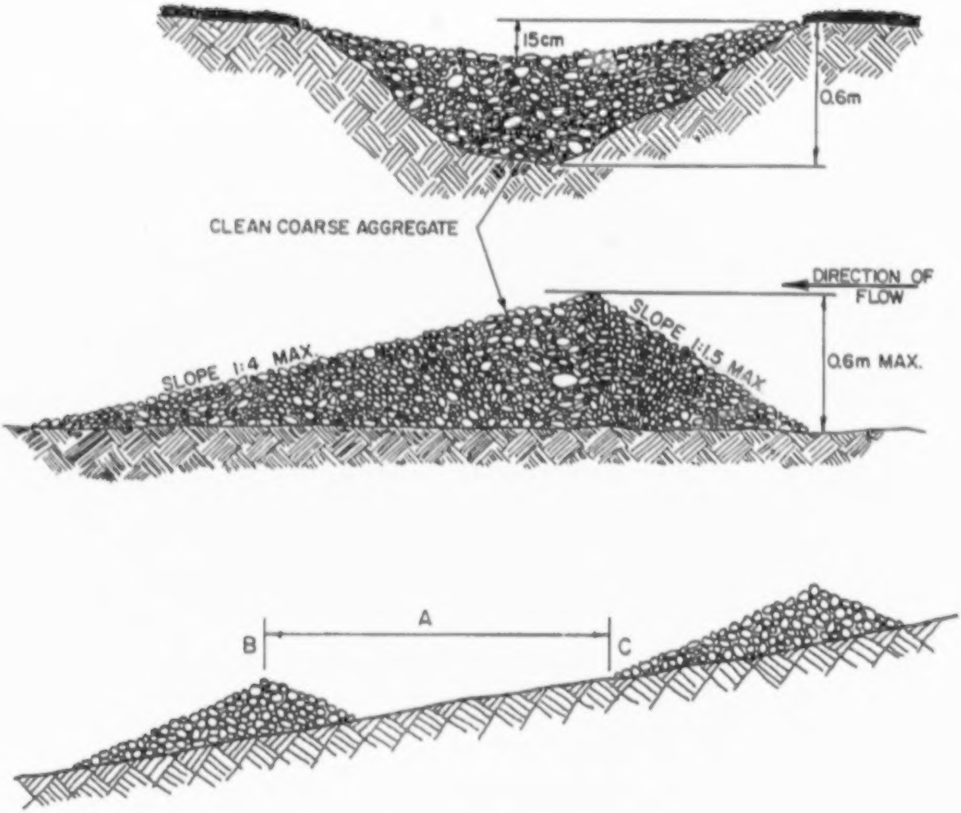
INSTALLATION

Check Dam

The center of the check dam must be at least 15 cm lower than the outer edges. The maximum spacing between dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam. To avoid impounding large quantities of water, check-dams should be under 0.6 m in height. See Figure 12.

Stone/rock check-dams should be constructed of 5 to 8 cm stone. Complete coverage of the ditch or swale is necessary and can be achieved with hand or mechanical placement. To reduce destruction of the downstream side, the slope should be 1V:4H (Figure 12). See **Section D BMP Specification Details.**

Figure 12: Stone/Rock Check Dam


15cm
0.6m
CLEAN COARSE AGGREGATE
DIRECTION OF FLOW
SLOPE 1:4 MAX.
SLOPE 1:1.5 MAX
0.6m MAX.
A
B
C

THE DISTANCE "A" SHALL BE SUCH THAT POINTS
"B" & "C" ARE OF EQUAL ELEVATION.

Log check-dams can be constructed from 10 to 15 cm logs. The 15 cm lower height required at the center can be achieved either by careful placement of the logs or by cutting the logs after they are in place (see Figure 13).

Strawbale Check Dam

1. Straw bale check dams should be constructed so the top of the downstream bale is approximately level with the lowest ground elevation of the upstream bale.

2. The straw bales should be oriented perpendicular to the contours.

3. The straw bales shall be extended to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale to ensure that sediment-laden runoff will not flow around the filter.

4. Sediment removal should take place when the level reaches about one half the height of the lowest (or flow line bales) and preferably sooner.

5. If channel side slopes are flatter than 7H:1V, consider alternative methods for stabilizing the channel.

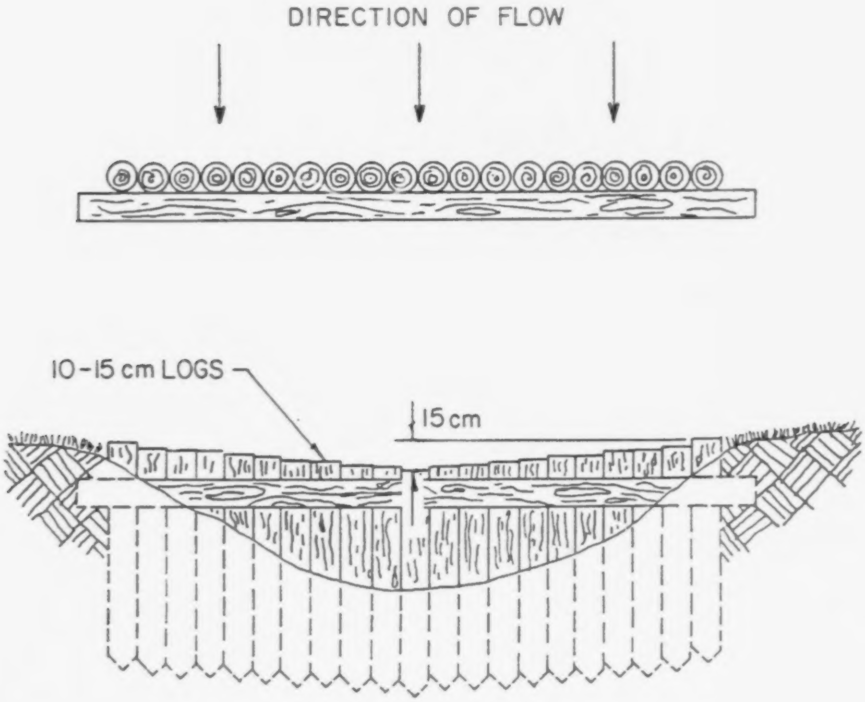
NOTE: In certain circumstances an apron or splash pad may be needed downstream of the check dams in highly erodible soil.

MAINTENANCE

Check dams should be checked after each significant rainfall. Necessary repairs should be made promptly, and sediment must be removed when it reaches one half of the original height or sooner.

The center of check-dams must remain lower than the edges. Erosion caused by high flows around the edges of the dam should be corrected immediately.

Figure 13: Log Check Dam



SPECIFICATIONS

Stone/Rock Check Dams

1. Aggregate for stone checkdams shall be composed of clean, hard, durable mineral particles of 5 to 8 cm size, free from organic matter, clay balls, soft particles or other substances. Not more than 15 per cent by weight, shall be flat, elongated particles. Aggregates may be accepted or rejected based on field performance.

2. The side slopes of stone/rock check dams shall have a vertical to horizontal ratio of 1V:1.5H on the upstream side and 1V:4H on the downstream side.

Log Check Dam

1. Logs for log check dams shall be composed of sound wood throughout and be 10 to 15 cm in diameter.

2. The logs for log check dams shall be imbedded into the soil at least 0.5

3. Log check dams must be designed to avoid undermining and outflanking around the end.

Strawbale Check Dam

1. Straw (or hay) bales shall be of one size, with straight sides and square corners, tightly packed and bound with at least two loops of wire or twine. Each bale should weigh at least 12 kg and preferably more.

2. Straw bales shall be placed in a single row, lengthwise, with ends tightly abutting adjacent bales. The wire or string bindings should be oriented around the sides rather than along the tops and bottoms of the bales in order to prevent early deterioration of the bindings.

3. The bales shall be embedded or trenched into the soil to a minimum depth of 10 cm. After the bales are staked and chinked, the excavated soil shall be backfilled and compacted against the filter.

4. Each bale shall be securely anchored by at least two stakes or re-bars driven through the bale. The first stake in each bale shall be driven toward the previously laid bale to force the bales together.

See **Section D BMP Specification Details** for more information.

SEDIMENT CONTROL MEASURE 4
SILT FENCES

INTRODUCTION

A silt fence is a sediment barrier that utilizes a standard strength or extra-strength filter fabric attached to a wire support fence. Silt fences slow the flow rate of runoff substantially and act as a filter to remove suspended sediment.

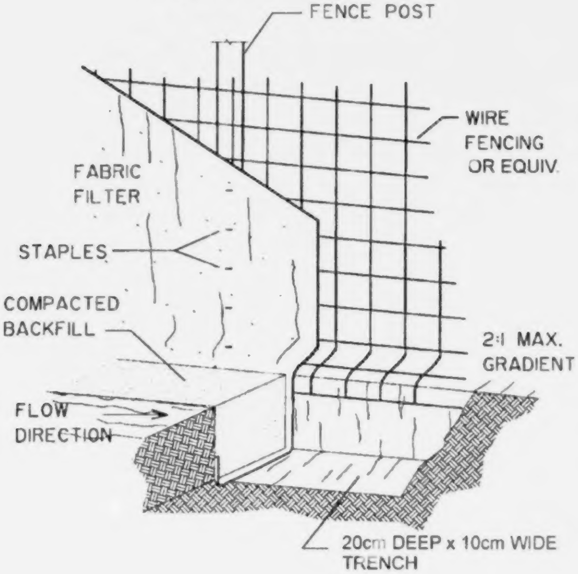
APPLICATION

Silt fences can be used to control sediment below disturbed areas where erosion would likely occur as sheet or rill erosion. They can also be used in areas where the size of the drainage area is not more than 0.1 ha/30 m of silt fence length, the maximum slope length behind the barrier is 30 m, the maximum gradient is 2H:1V, and in small swales and along ditches where 1 ha is the maximum contributing drainage area. Silt fences are not to be constructed in areas where flows are expected to exceed 0.03 m^3/s. As a result, silt fences constructed through V ditches are not generally recommended.

DESCRIPTION

Silt fence fabric may be composed of natural or synthetic material. Woven and non-woven fabrics are commercially available with the woven fabrics generally having higher strength. Permeability rates vary and there is considerable variation when filtering the finer silt and clay particles. See Figure 14 and Specifications for Silt Fences.

Figure 14: Silt Fence



Silt fences with low permeability have a high filtering capacity. However, such fabrics may not have sufficient structural strength to support the weight of water ponded behind the fence line.

Posts of either wood or steel may be used to support the fence. Wire fencing may be used to help support the fabric, depending upon the fabric's strength. Standard wire and wood slat snow fencing is generally recommended.

The height of a silt fence should not exceed 1 m so as not to impound dangerously large quantities of water. A silt fence is a temporary barrier with a usable life of about six months.

INSTALLATION

Proper silt fence installation is critical to effectively control erosion and sediment control. If correctly installed, silt fences help prevent topsoil from migrating off construction sites and protect adjacent property for the effects of siltation.

Silt fences that are intended to intercept overland flows should be surveyed to ensure they are constructed parallel to slope contours. An anchor trench is first excavated along the contour on the upslope side of the barrier. The posts are then set firmly into the ground.

The wire mesh or standard snow fencing support fence (if used) is then fastened securely to the upslope sides of the posts, extending into the trench and not exceeding 1 m above the ground surface.

The fabric is then extended into the trench and stapled or wired to the fence. The reinforced fence may be eliminated if an extra strength filter fabric and a closer post spacing pattern is used. The filter shall then be stapled or wired directly to the support posts.

The trench is then backfilled and the soil is compacted over the filter fabric to ensure that no gaps between ground and fabric exist. **It should be noted that silt fences do not work without proper trenching and compacted backfill.** See **Section D BMP Specification Details** also.

MAINTENANCE

Inspection of the silt fence must be conducted immediately after heavy rainfall and daily during prolonged rainfall. Repairs to the fence must be completed immediately, and any section of the fence which decomposes before the end of its expected use shall also be replaced immediately. The biggest mistake made with silt fence is to install it and forget about it. Regular inspection and maintenance is key to silt fence effectiveness.

Sediment trapped in the filter should be inspected and removed as required. **When these deposits reach one-half the height of the barrier, they must be**

removed. Once their useful purpose has been fulfilled, silt fences should be removed. However, this shall not occur until after the upslope area has been permanently stabilized. After removal of the silt fence, the sediment which remains in place must be graded, prepared and seeded.

SPECIFICATIONS

1. The post used for supporting a silt fence shall be either 10 cm diameter wood or 2 kg per linear meter steel, with a minimum length of 1.5 m. The steel posts must also have projections to enable the fastening of wire to them.

2. The posts shall be set at a maximum spacing of 3 m and driven at least 35 cm into the ground. When a wire support fence is not used, posts shall not be spaced more than 2 m apart.

3. The anchor trench shall be a minimum 20 cm deep x 10 cm wide and shall be excavated along the post line on the upslope side of the barrier.

4. For silt fences using a standard strength filter cloth, the reinforcement fence, if used, shall be a minimum of 1.1 m in height, have a maximum mesh spacing of 15 cm, and have a minimum wire diameter of 2 mm. It shall be fastened securely to the upslope sides of the posts with heavy duty staples of a minimum of 25 cm in length, or with tie wires or hog rings, providing standard strength fabric is used. The fence shall extend a minimum of 5 cm into the trench and shall not exceed 1 m above the ground surface.

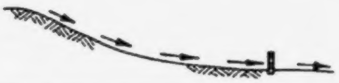
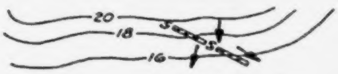
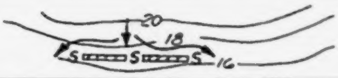
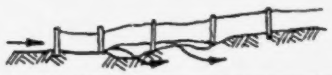
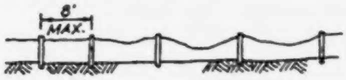
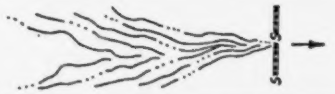
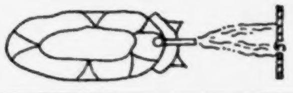
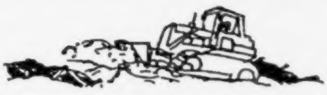
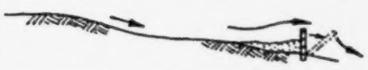
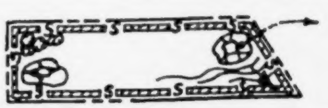
5. A pervious synthetic filter fabric, such as propylene, nylon, polyester or ethylene yarn may be used. The fabric, in order to provide a minimum construction life of six months, at a temperature range of -18^0 C to 50^0 C, shall contain ultraviolet ray inhibitors and stabilizers. Pervious and closely woven natural fiber fabric may also be used in place of synthetic fabric. However, porosity and filtering capability must be comparable to synthetic material. In order to avoid the use of joints, the fabric shall be from a continuous roll, cut to the length of the barrier.

6. 20 cm of the fabric, standard strength, shall be extended into the trench and shall be stapled or wired to the fence (or directly to the posts if a fence is not used). However, the fabric shall not extend more than 1 m above the ground surface and it shall not be stapled to existing trees.

7. The trench shall be backfilled and the soil compacted over the filter fabric.

Silt fence effectiveness can be limited by several conditions (see Figure 15). Care should be taken to limit these conditions or situations.

Figure 15: Conditions that Limit Silt Fence Effectiveness

1		**Slope and/or Length of Slope** 5% to 10%: no more than 50 feet 10% to 20%: no more than 25 feet more than 20%: no more than 15 feet
2		Silt fence is not **aligned parallel** to slope contours
3		Edges of the silt fence are not **curved uphill**, allowing flow to bypass the fence
4		**Contributing length** to fence is greater than 100 feet
5		Fabric is not **entrenched deeply** enough to prevent undercutting
6		**Spacing between posts** is greater than eight feet
7		Fence receives **concentrated flow** without reinforcement
8		Installed **below an outlet pipe** or weir
9		Silt fence is ***upslope*** of the exposed area
10		Silt fence alignment does not consider **construction traffic**
11		**Sediment deposits** behind silt fence reduce capacity and increase breach potential
12		Alignment of silt fence **mirrors the property line** or limits of disturbance, but does not reflect ESC needs

Source: Watershed Protection Techniques, 1997

SEDIMENT CONTROL MEASURE 5
GEOSYNTHETIC PERMEABLE BERMS

INTRODUCTION

Low profile, uni-body permeable berms are used to reduce water (or wind) velocity over soil, with the intent of reducing or preventing transport of fine soil particles. They provide portable drainage control for construction sites, channels, roads and slopes. Porous berms allow a smoother and less damaging release of water through the berms as opposed to allowing water to cascade over a solid berm, such as strawbales. By controlling the velocity of the water, the migration of sediment is controlled.

APPLICATION

Geosynthetic, uni-body permeable berms should be constructed at the perimeter of disturbed slopes areas, parallel to the slope contours. They can also be used in small channels to prevent gully erosion during site construction. The system is comprised of a series of synthetic, porous berms installed perpendicular to the direction of flow. While each individual berm captures sediment, the series of berms functions as a large sediment filter which gradually improves water quality as the sediment load is removed from the runoff.

DESCRIPTION

Geosynthetic, uni-body berms provide effective barriers, which are designed for repeated use. Typically, these permeable berms are designed to compliment the performance of erosion control blankets in channel and slope applications. The composite sediment/erosion control system can also be used as an alternate to hard armor in high flow applications. The permeable berms can also be left in place for final channel stabilization since there is no degradation.

INSTALLATION

It is recommended that an erosion control blanket be used in conjunction with the geosynthetic, uni-body permeable berm. All installations should be as per the manufacturer's recommendations.

The recommended spacing is directly related to the channel grade. As channel grade increases, check spacing decreases. In general, the recommended spacing is:

$$\text{Maximum berm spacing (m)} = \frac{\text{Height of Permeable Berm (m)}}{\text{Channel Slope (m/m)}}$$

1. Prepare channel by forming the shape and grade of the channel and compacting the subgrade.

2. Survey locations of ditch checks along the length of the channel (according to the spacing equation).

3. Place geosynthetic permeable berms perpendicular to the direction of flow. Panels should be overlapped by a minimum of 50 mm. Cut a slot in the crest of the overlapping berm to allow contact between the foot of the berm and the soil.

4. Install a 2m wide erosion control blanket perpendicular to the direction of flow, centered under the permeable berm. Allow 100 mm of slack across the blanket width for folding over the upstream foot of the permeable berm. Provide a 15 cm x 15 cm trench at the upstream edge of the blanket. Staple blanket to the bottom of the trench with minimum 15 cm long staples spaced at 50 cm centers. Re-compact soil in trench.

5. Secure berms with 25 cm galvanized long spikes with washers through the foot of the unit. Spike spacing across the width of the panel should be 25 cm on the upstream leg and 50 cm on the downstream leg.

MAINTENANCE

Silt deposited behind the permeable berms must be removed periodically to maintain permeability and performance of the berms. Allowing excessive sediment to build up behind the berm will create a non-porous check structure. As water flows over the plugged berm, the impact of the runoff on the downstream side will promote the dislodgment and transportation of sediment, leading to failure of the system.

SEDIMENT CONTROL MEASURE 6
DRAIN INLET PROTECTION

INTRODUCTION

Drain inlet protection prevents course sediment from entering the underground storm pipe system prior to permanent stabilization of the disturbed areas. This is generally accomplished by using a small sediment trap around the storm drain, primarily in trap low locations. The trap slows the runoff velocity and aids in sedimentation prior to the runoff entering the drain inlet.

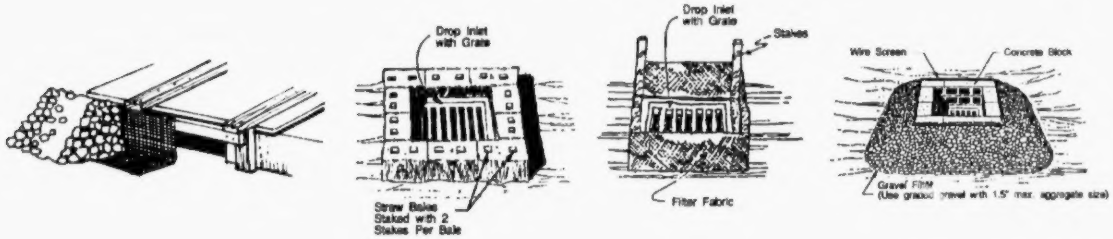
APPLICATION

Inlet protection should be used where storm drain inlets are operational prior to permanent stabilization of the disturbed drainage area. Inlet protection can be effective where drainage enters the municipal sewer system or a watercourse.

DESCRIPTION

Drain inlet protection can be formed using sod, straw bales, rock or man made fiber filters which trap the sediment before it enters the system. See Figure 16.

Figure 16: Types of Drain Inlet Protection


Drop Inlet with Grate
Straw Bales Staked with 2 Stakes Per Bale
Drop Inlet with Grate
Stakes
Filter Fabric
Wire Screen
Concrete Block
Gravel Filter
(Use graded gravel with 1.5" max. aggregate size)

INSTALLATION

Gravel Filters Inlet Drain

Placement of gravel filters around inlet drains must be completed in a manner that will not cause local flooding.

Gravel filters can be used if the immediate and adjacent area to the inlet drain consists of soil or pavement. **Only gravel filters shall be installed on top of the pavement.**

1. Place concrete blocks around the grate. The blocks can be stacked one or two high and should be supported by a 5 cm x 10 cm board.

2. Wrap 13 mm (½ in) mesh wire screen around the concrete blocks.

3. Place 25 mm to 38 mm diameter rock around the blocks and wire screen. Be sure the rock extends down from the top of the concrete block.

4. To prevent damage to vehicles, signs warning drivers about the structures may be necessary.

An alternative method is to use gravel bags to prevent collapsing. Use of rock having diameters smaller than 25 mm (1 inch) may result in clogging of pores and reduce the amount of water flowing into an inlet.

Gravel Filter Curb Inlet

A gravel filter shall be installed only when a curb inlet is in a sump location. Otherwise, the possibility exists that runoff waters will be diverted from the inlet and cause downstream flooding. See **Section D BMP Specification Details** for more information.

1. Place concrete blocks around the inlet so a "U" shape is formed. The blocks must be supported by a 5 cm x 10 cm (2 in x 4 in) board placed along the curb.

2. Wrap 13 mm (½ in) mesh wire screen around the concrete blocks.

3. Place 25 mm to 38 mm diameter rock around the blocks and wire screen. Be sure the rock extends down from the top of the concrete block.

4. To prevent damage to vehicles, signs warning drivers about the structures may be necessary.

An alternative installation is to use gravel bags supported by a 5 cm x 10 cm board to prevent collapsing. Use of rock smaller than 25 mm (1 inch) in the bag may result in clogging of pores and reduce the amount of water flowing into an inlet.

MAINTENANCE

Gravel Filter Inlet Drain

All gravel filters installed around inlet drains should be inspected and repaired after each runoff event. Sediment should be removed when material is within 8 cm (3 inches) of the top of any block. Periodically, the gravel should be raked to increase infiltration and filtering of runoff waters. Accumulated sediment is to be removed immediately from roads and streets.

Gravel Filter Curb Inlet

All gravel filter curb inlets shall be inspected and repaired after each runoff event. Sediment deposits are to be removed once material is within 8 cm (3 inches) of the top of any block. Periodically, the gravel shall be raked to increase infiltration and filtering of runoff waters. Accumulated sediment is to be removed immediately from roads and streets.

SPECIFICATIONS

Inlet Filters should be installed as per manufacturer's recommendations. Other products may be available. Contact Wastewater & Drainage and/or Urban Development for approval.

SEDIMENT CONTROL MEASURE 7
SEDIMENT TRAPS

INTRODUCTION

A sediment trap is a small temporary ponding area that is used to collect and store sediment-laden runoff. Typically, there is a gravel outlet. Sediment traps are used to slow runoff flow velocity, prior to entering a drainage inlet, in order to settle out some sediment. Sediment traps are generally simple and inexpensive to install.

APPLICATION

Sediment traps are temporary structures designed to remove soil particles suspended in runoff waters from **2 ha (5.0 acres) or less** of disturbed lands. If contributory lands exceed 2 ha, installation of a properly designed sediment basin/pond is recommended.

As with sediment basins, traps are not capable of removing 100% of the soil particles suspended in runoff waters. However, when properly installed, they may remove up to 75% of sediment in runoff waters depending upon the upstream soil types and design precipitation event.

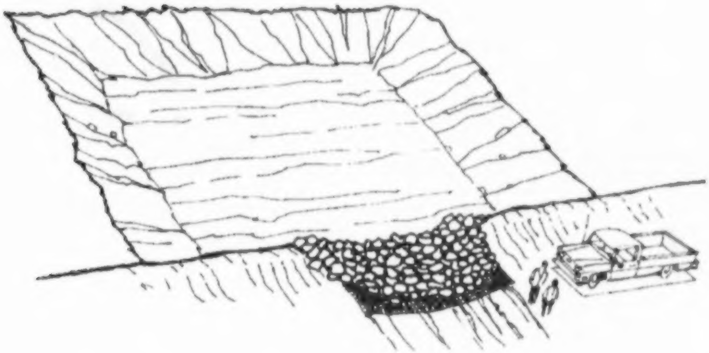
The use of check-dams is also a form of sediment trap. When flow velocity is reduced, the heavier sediment particles settle out. The use of sand bags in natural waterways on a site to create small dams will cause the water to drop part of its sediment load. Similarly, the placement of large rocks in front of sewer inlets will detain and pond stormwater. This will cause sedimentation, as well as a reduction of soil erosion at the sewer inlet. Refer **to Sediment Control Measure 6 Drain Inlet Protection** for further information.

DESCRIPTION

The underlying feature of a sediment trap is the formation of a pond to slow the rate of flow, cause sediment to settle out, and allow storage of sediment. Sediment traps are only effective in removing sediment down to the medium silt size fraction. Finer fractions (fine silt and clay) will pass through untreated. Therefore, erosion control is still needed. See Figure 17. For more detailed information, refer to Specifications for Single and Double Sediment Traps.

If soils are predominantly clay, the effectiveness may be less than 75%. Understanding upstream soil conditions is important when installing sediment traps.

Figure 17: Typical Sediment Trap



INSTALLATION

Identify upstream soils that may flow into the trap.

Decide whether a single or double chamber trap can be installed on the land available. The total width of each type of trap shall be nearly the same. Only the length will be different. Refer to **Section D BMP Specification Details**.

Install an outlet filter using a mixture of 8 cm to 15 cm (3 in to 6 in) diameter rock. **It is important that a minimum 25 cm (10 in) depression exist in the rocks to accommodate overflow conditions.**

Develop the containment berm by excavating bottom material necessary to create an average pond depth of at least 75 cm (30 in). Additional material may need to be imported. If desired, the containment berm may be constructed out of riprap having a mixture of 8 cm to 20 cm (3 in to 8 in) diameter rock.

MAINTENANCE

As runoff waters enter the sediment trap, sedimentation will occur and eventually fill the pond. **Accumulated material is to be removed once sediment accumulates within 38 cm (15 in) of the overflow depression. Therefore, sediment removal would typically occur when the design storage level is 1/3 to ½ full.**

When significant runoff flows enter the trap and destroy an embankment or rock filter, repairs are to be completed immediately. The rock berm used to create a double chamber must be maintained at all times to ensure that a proper flow path length exists. If necessary, additional riprap may be installed at locations where possible embankment erosion can occur.

SPECIFICATIONS

In general, sediment traps should be sized for **a minimum storage volume of 150 m^3/ha** over the contributing drainage area. **Storage volumes of 250 m^3/ha are recommended where site conditions and construction practices warrant higher sediment trapping.**

SEDIMENT CONTROL MEASURE 8
SEDIMENT PONDS

INTRODUCTION

Sediment ponds or basins are temporary ponding areas that are used to collect and store sediment-laden runoff. They function similar to sediment traps in that runoff velocity is slowed to promote sedimentation. Where a sediment pond differs is with respect to the contributing drainage area it services.

APPLICATION

Sediment ponds are temporary structures designed to remove soil particles suspended in runoff waters from disturbed lands **exceeding 2 ha (5.0 acres)** in size.

Sediment basins are not capable of removing 100% of the soil particles suspended in runoff waters. However, when properly installed, they may remove up to 75% of sediment in runoff waters depending upon the upstream soil types and design precipitation event.

DESCRIPTION

The underlying feature of a sediment pond is the formation of a pond to slow the rate of flow, cause sediment to settle out, and allow storage of sediment. However, due to their size, sediment ponds should be installed only on sites where failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment ponds can be attractive to children and therefore be dangerous.

INSTALLATION

Identify the contributing drainage area and the type of upstream soils that may flow into the sediment pond.

Develop the containment berm by excavating bottom material necessary to create an average pond depth of 1 m. A maximum depth of 1.5 m should **not** be exceeded.

An emergency spillway composed of riprap must be included as part of the design. As well, an outlet riser pipe, or approved equivalent must be incorporated in the pond design.

MAINTENANCE

As runoff waters enter the sediment pond, sedimentation will occur and eventually fill the pond. **Accumulated material is to be removed once sediment reaches 30 cm (12") in depth.**

When significant runoff flows enter the pond and destroy an embankments or slopes, repairs are to be completed immediately. Riprap can be used to protect areas in the pond subject to increased erosion potential.

SPECIFICATIONS

1. In general, sediment ponds or basins should be sized for **a minimum storage volume of 250 m^3/ha** over the contributing drainage area, where possible. **This corresponds to the minimum water quality control volume required for permanent facilities.** All sediment pond designs must be carried out by qualified engineering design consultants.

2. Length to Width ratio should be between 3:1 and 6:1.

3. The maximum pond depth should **not** exceed 1.5 m.

4. The sediment pond bottom should be flat. Interior facing side slopes should not exceed 3H:1V maximum, providing safety is not a concern. Otherwise, milder side slopes (i.e. 5H:1V) should be used. Fencing is an option if safety is a great concern.

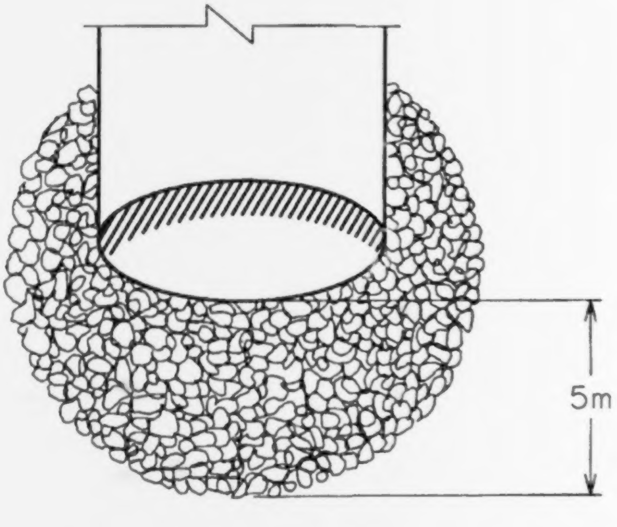
SECTION D

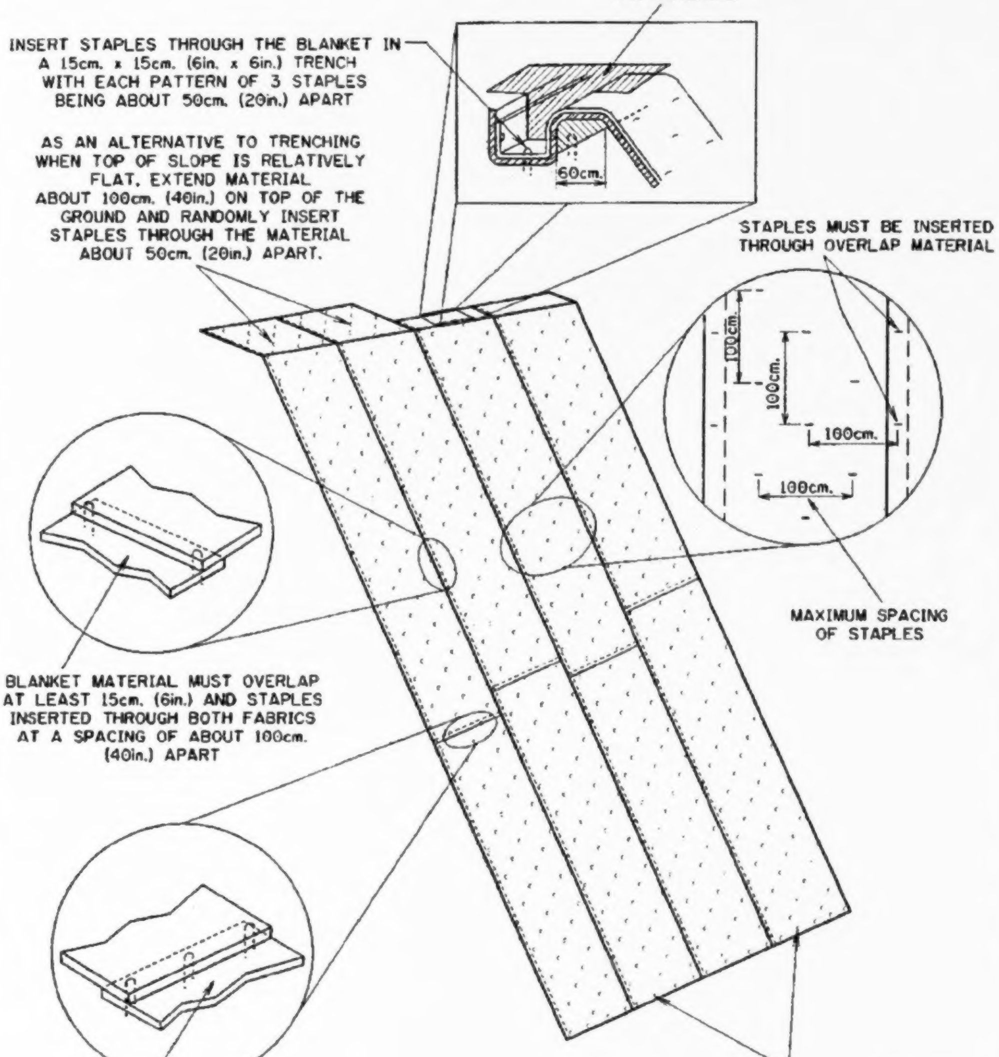
BMP SPECIFICATION DETAILS

RIP RAP SPEC.

N.T.S.

AT THE 1880 x 1260mm CULVERT. SPECIFY 200-300mm RIP RAP IN A 5m RADIUS SEMI-CIRCLE FROM THE EDGE OF INVERT OF THE CULVERT. TAPER UP ALONG THE SIDES TO THE SPRINGLINE AT BOTH THE UPPER AND LOWER END.





BACKFILL AND COMPACT DIRT IN THE 15cm. x 15cm. (6in. x 6in.) IN TRENCH AFTER INSERTING STAPLES THROUGH THE MATERIAL

INSERT STAPLES THROUGH THE BLANKET IN A 15cm. x 15cm. (6in. x 6in.) TRENCH WITH EACH PATTERN OF 3 STAPLES BEING ABOUT 50cm. (20in.) APART

AS AN ALTERNATIVE TO TRENCHING WHEN TOP OF SLOPE IS RELATIVELY FLAT, EXTEND MATERIAL ABOUT 100cm. (40in.) ON TOP OF THE GROUND AND RANDOMLY INSERT STAPLES THROUGH THE MATERIAL ABOUT 50cm. (20in.) APART.

STAPLES MUST BE INSERTED THROUGH OVERLAP MATERIAL

BLANKET MATERIAL MUST OVERLAP AT LEAST 15cm. (6in.) AND STAPLES INSERTED THROUGH BOTH FABRICS AT A SPACING OF ABOUT 100cm. (40in.) APART

MAXIMUM SPACING OF STAPLES

BLANKET MATERIAL MUST OVERLAP AT LEAST 15cm. (6in.) AND STAPLES INSERTED THROUGH BOTH FABRICS AT A SPACING OF ABOUT 50cm. (20in.) APART

AT THE END OF SLOPE, SECURE BLANKET MATERIAL BY INSERTING STAPLES ABOUT 50cm. (20in.) APART THROUGH THE FABRIC

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METRIC

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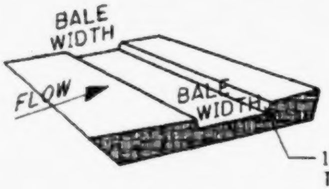
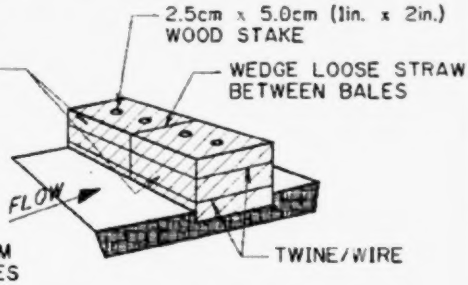
HILLSIDE BLANKET INSTALLATION

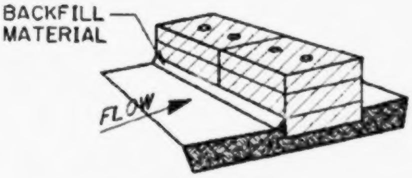
Sheet
File Number


BALE WIDTH
FLOW
BALE WIDTH
10cm (4in.) MINIMUM TRENCH FOR BALES

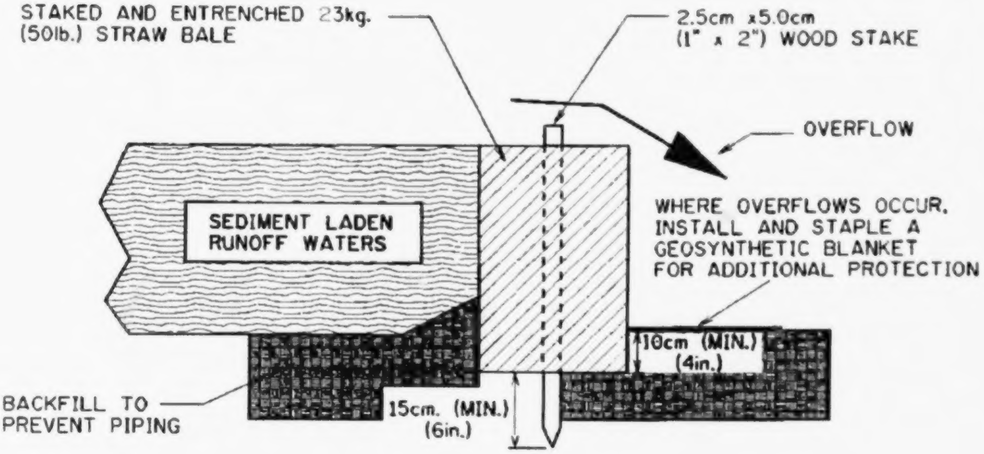
1. EXCAVATE THE TRENCH


BALES MUST BE TIGHTLY ABUTTING WITH NO GAPS
2.5cm x 5.0cm (1in. x 2in.) WOOD STAKE
WEDGE LOOSE STRAW BETWEEN BALES
FLOW
TWINE/WIRE

2. PLACE AND STAKE STRAW BALES


BACKFILL MATERIAL
FLOW

3. BACKFILL AND COMPACT EXCAVATED SOIL


STAKED AND ENTRENCHED 23kg. (50lb.) STRAW BALE
2.5cm x5.0cm (1" x 2") WOOD STAKE
OVERFLOW
SEDIMENT LADEN RUNOFF WATERS
WHERE OVERFLOWS OCCUR, INSTALL AND STAPLE A GEOSYNTHETIC BLANKET FOR ADDITIONAL PROTECTION
10cm (MIN.) (4in.)
BACKFILL TO PREVENT PIPING
15cm. (MIN.) (6in.)

CROSS SECTION OF A PROPERLY
INSTALLED STRAW BALE

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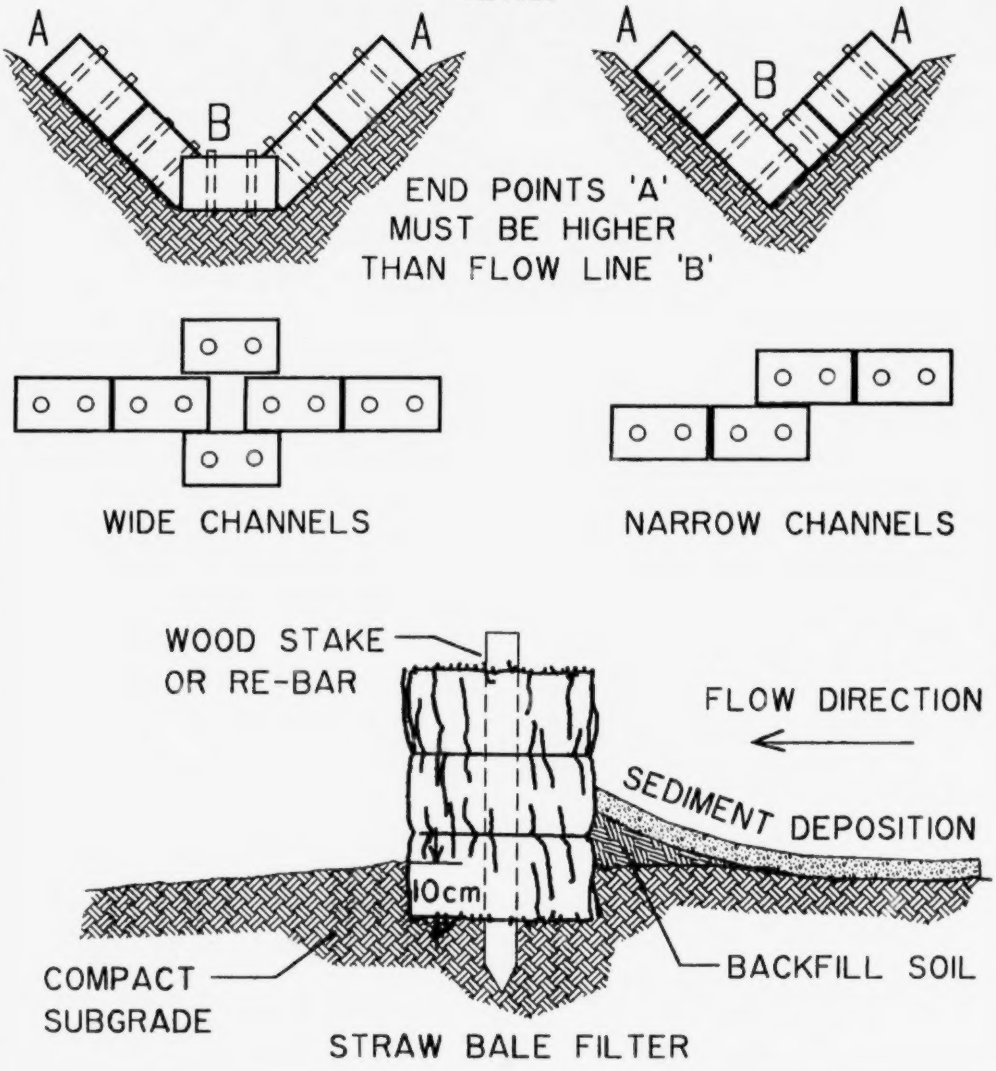
INSTALLATION OF
STRAW BALES

Sheet
File Number

STRAW BALE CHANNELS & FILTER

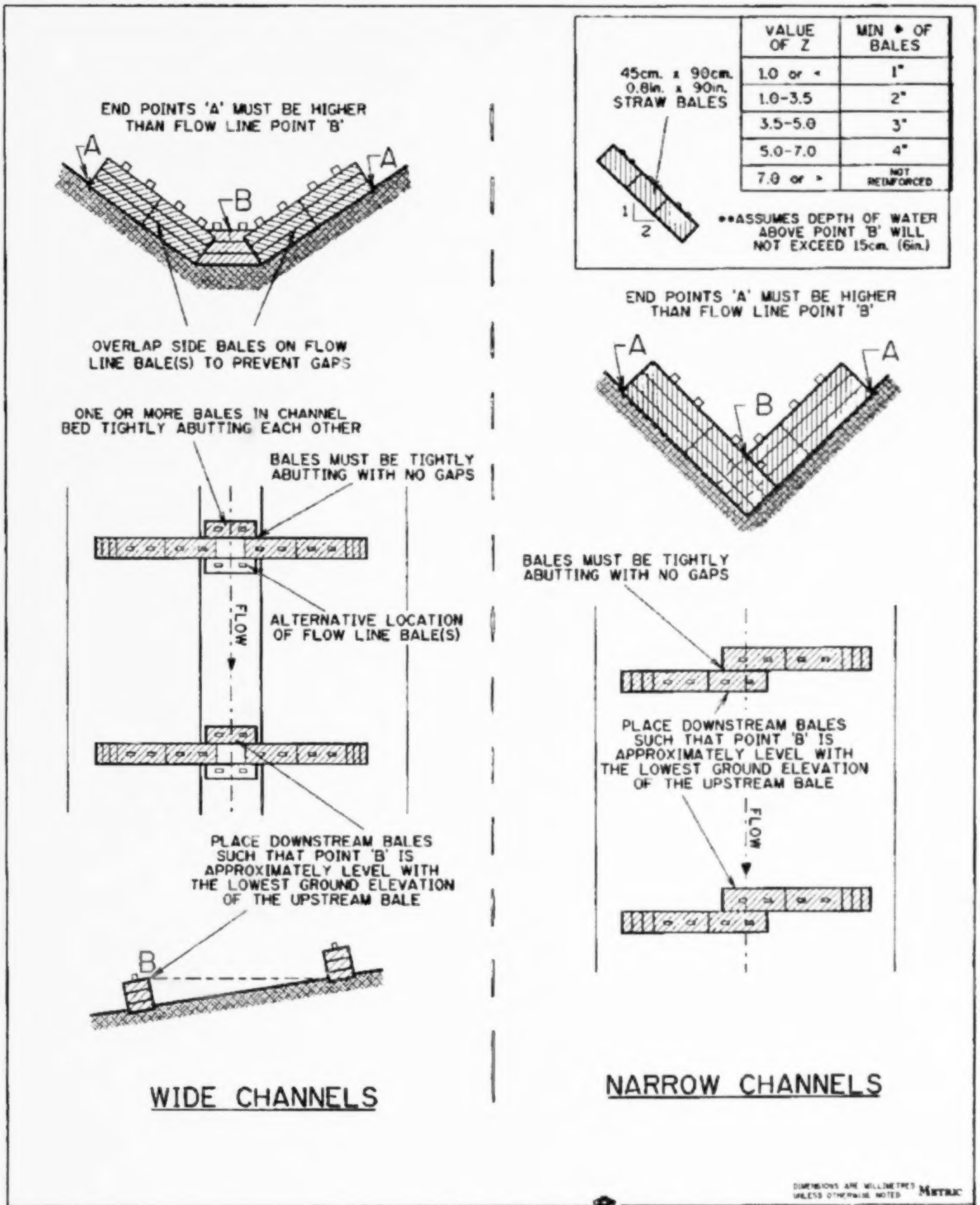
N.T.S.


A
A
B
A
A
B
END POINTS 'A' MUST BE HIGHER THAN FLOW LINE 'B'
WOOD STAKE OR RE-BAR
FLOW DIRECTION
SEDIMENT DEPOSITION
10cm
BACKFILL SOIL
COMPACT SUBGRADE

WIDE CHANNELS

NARROW CHANNELS

STRAW BALE FILTER


END POINTS 'A' MUST BE HIGHER THAN FLOW LINE POINT 'B'
A
A
B
OVERLAP SIDE BALES ON FLOW LINE BALE(S) TO PREVENT GAPS
ONE OR MORE BALES IN CHANNEL BED TIGHTLY ABUTTING EACH OTHER
BALES MUST BE TIGHTLY ABUTTING WITH NO GAPS
FLOW
ALTERNATIVE LOCATION OF FLOW LINE BALE(S)
PLACE DOWNSTREAM BALES SUCH THAT POINT 'B' IS APPROXIMATELY LEVEL WITH THE LOWEST GROUND ELEVATION OF THE UPSTREAM BALE
B
WIDE CHANNELS
45cm. x 90cm. 0.8in. x 90in. STRAW BALES
1
2
END POINTS 'A' MUST BE HIGHER THAN FLOW LINE POINT 'B'
A
A
B
BALES MUST BE TIGHTLY ABUTTING WITH NO GAPS
PLACE DOWNSTREAM BALES SUCH THAT POINT 'B' IS APPROXIMATELY LEVEL WITH THE LOWEST GROUND ELEVATION OF THE UPSTREAM BALE
FLOW
NARROW CHANNELS

VALUE OF Z	MIN # OF BALES
1.0 or <	1*
1.0-3.5	2*
3.5-5.0	3*
5.0-7.0	4*
7.0 or >	NOT REINFORCED

**ASSUMES DEPTH OF WATER ABOVE POINT 'B' WILL NOT EXCEED 15cm. (6in.)

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STRAW BALE DROP STRUCTURES FOR DRAINAGE CHANNELS

Sheet
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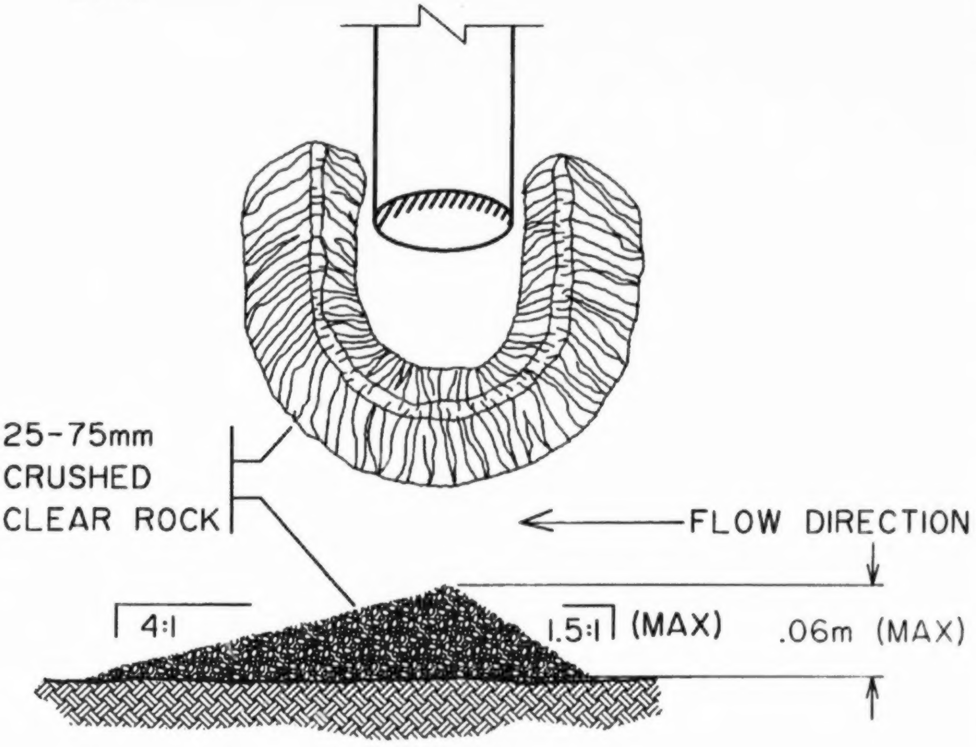
ROCK CHECK DAM

N.T.S.

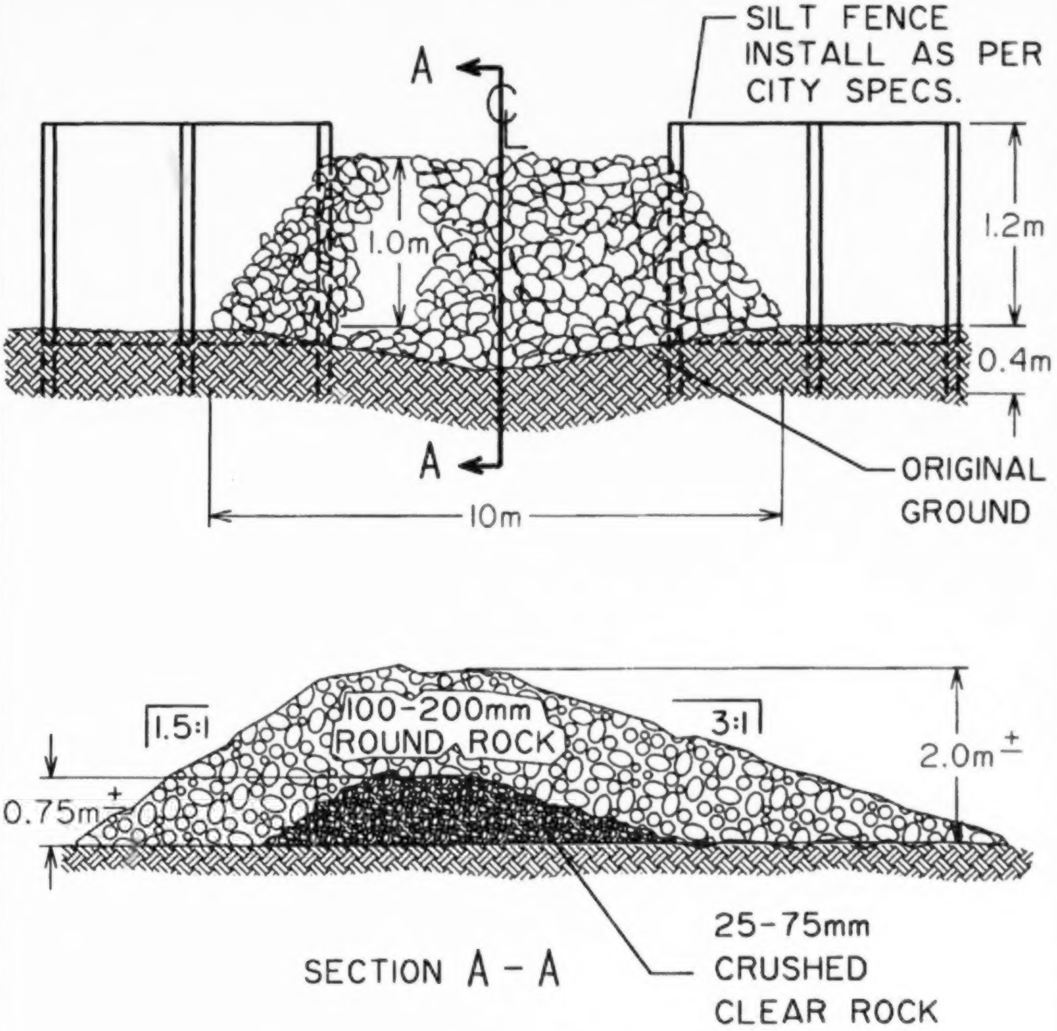
AT THE 600mm CULVERTS, THE INLET IS TO BE PROTECTED WITH A ROCK FILTER CHECK DAM.


25-75mm
CRUSHED
CLEAR ROCK
FLOW DIRECTION
4:1
1.5:1 (MAX)
.06m (MAX)

AT F.A.C. THE ROCK CHECK DAMS SHOULD BE REMOVED AND THE AREA SODDED.

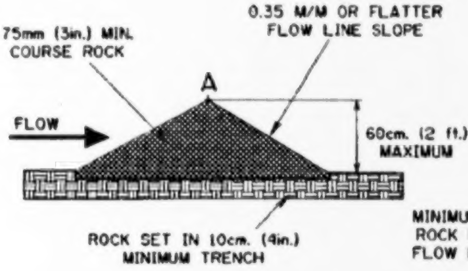
LARGE ROCK CHECK DAM

N.T.S.

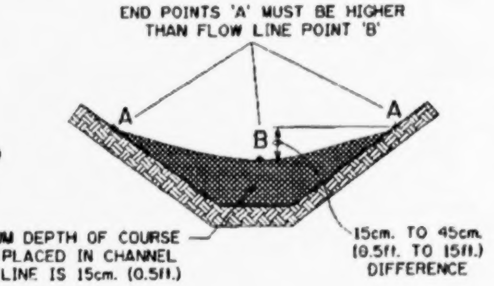

SILT FENCE
INSTALL AS PER
CITY SPECS.
A
℄
A
1.0m
1.2m
0.4m
ORIGINAL
GROUND
10m
1.5:1
100-200mm
ROUND ROCK
3:1
2.0m ±
0.75m ±
25-75mm
CRUSHED
CLEAR ROCK
SECTION A - A

D-50 OF ROCK (mm)	DOWNSTREAM FLOWLINE OF SLOPE OF STRUCTURE (mm)					
	0.35	0.30	0.25	0.20	0.15	0.10
	MAXIMUM WATER DEPTH OVER ROCK (mm)					
75	15	18	20	25	33	48
150	30	36	41	50	66	100

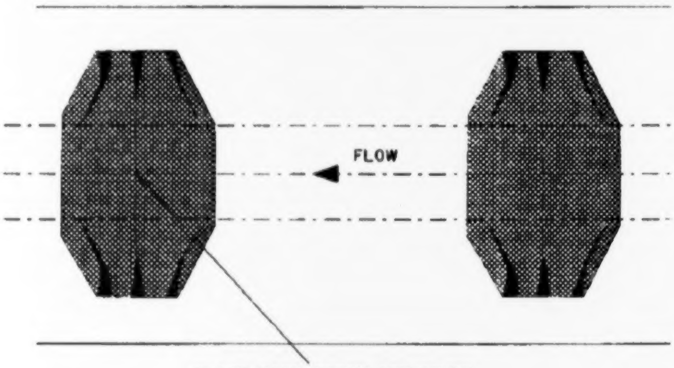
RECOMMENDED ROCK SIZE & FLOW DEPTHS


75mm (3in.) MIN.
COURSE ROCK
0.35 M/M OR FLATTER
FLOW LINE SLOPE
A
FLOW
60cm. (2 ft.)
MAXIMUM
ROCK SET IN 10cm. (4in.)
MINIMUM TRENCH

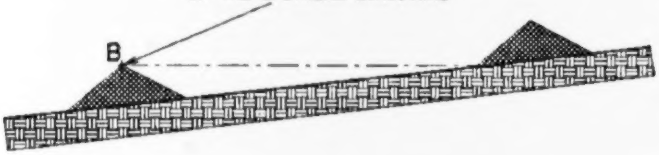
SIDE VIEW


END POINTS 'A' MUST BE HIGHER
THAN FLOW LINE POINT 'B'
A
A
B
MINIMUM DEPTH OF COURSE
ROCK PLACED IN CHANNEL
FLOW LINE IS 15cm. (0.5ft.)
15cm. TO 45cm.
(0.5ft. TO 15ft.)
DIFFERENCE

FRONT VIEW



PLACE DOWNSTREAM STRUCTURE
SUCH THAT POINT 'B' IS
APPROXIMATELY LEVEL WITH
THE LOWEST GROUND ELEVATION
OF THE UPSTREAM STRUCTURE



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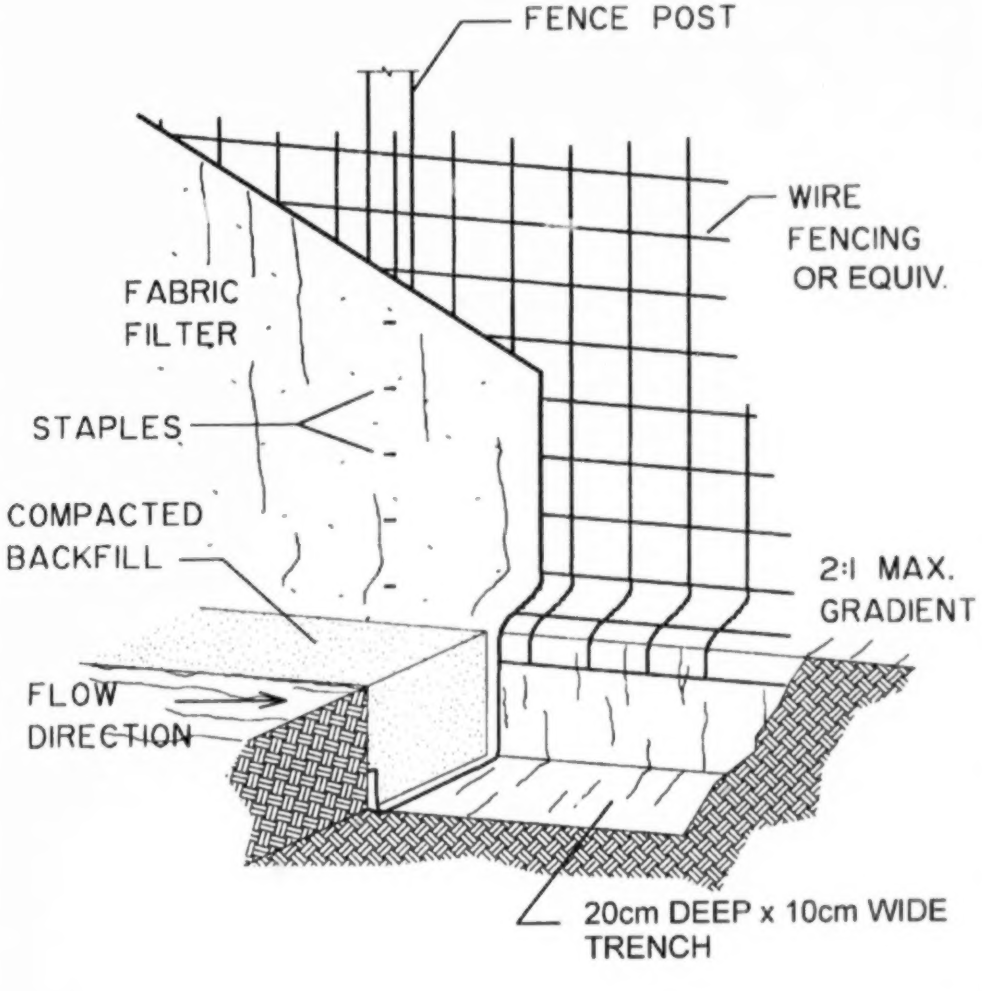
**SMALL ROCK CHECK
STRUCTURE FOR WIDE OR
NARROW DRAINAGE CHANNELS**

Sheet
File Number

SILT FENCE

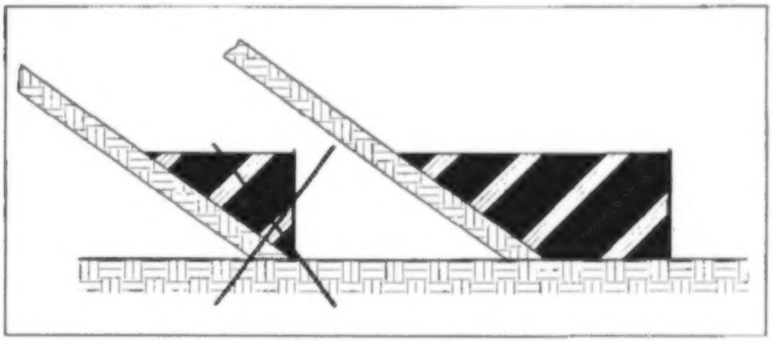
N.T.S.


FENCE POST
WIRE FENCING OR EQUIV.
FABRIC FILTER
STAPLES
COMPACTED BACKFILL
2:1 MAX. GRADIENT
FLOW DIRECTION
20cm DEEP x 10cm WIDE TRENCH

SILT FENCE BARRIERS

SILT FENCE (ALSO KNOWN AS FILTER FENCES) BARRIERS FUNCTION SIMILAR TO STRAW BALES. THEY CAN MINIMIZE SEDIMENT ENTERING STREAMS AND OTHER WATER BODIES AS WELL AS PROTECT ADJACENT PROPERTIES.

WHEN USED TO CONTROL SEDIMENT FROM STEEP SLOPES, SILT FENCES SHOULD BE PLACED AWAY FROM THE TOE OF SLOPE FOR INCREASED HOLDING CAPACITY.



INSTRUCTIONS FOR INSTALLING

STEP 1: DIG A 10 to 15cm WIDE x 20cm DEEP TRENCH

STEP 2: ROLL OUT FABRIC MATERIAL ALONG THE FRONT OF THE TRENCH SO THE STAKES SHALL BE ON THE DOWNSTREAM SIDE WITH THE BOTTOM FLAP LAYING IN THE TRENCH.

STEP 3: STARTING AT ONE END, DRIVE THE FIRST STAKE FAR ENOUGH INTO THE GROUND SO THAT ABOUT 20cm OF FLAP MATERIAL LIES IN THE TRENCH.

STEP 4: AT THE NEXT STAKE, PULL THE MATERIAL TAUNT BEFORE DRIVING IT INTO THE GROUND.

STEP 5: REPEAT STEP 4 UNTIL THE SILT FENCE IS INSTALLED.

STEP 6: WHEN ATTACHING TWO FENCES, USE THE ROTATION METHOD ILLUSTRATED IN THE DRAWING.

STEP 7: BACKFILL THE TRENCH AND COMPACT THE SOIL.

ADDITIONAL FABRIC MATERIAL STABILITY CAN BE REALIZED BY ATTACHING AN ANCHOR AS ILLUSTRATED IN THE DRAWING.

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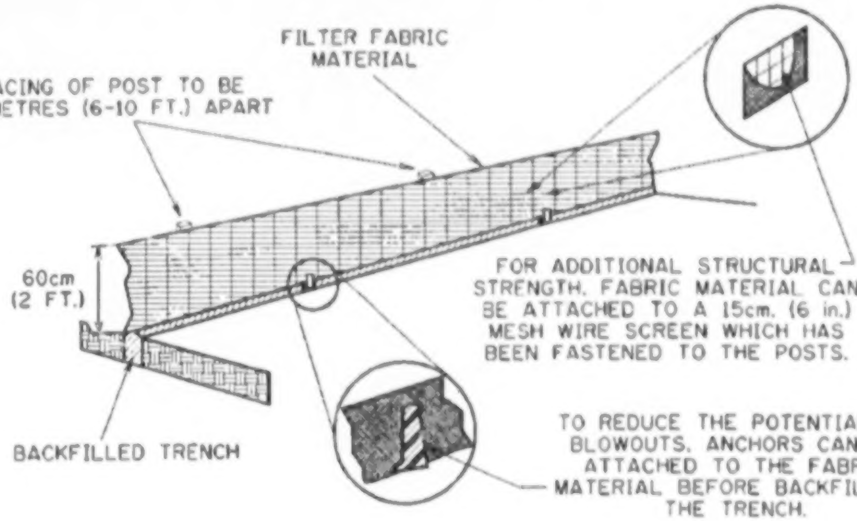
				Scale N.T.S.			SILT FENCE BARRIERS	File Number
				Approved by For City Engineer				

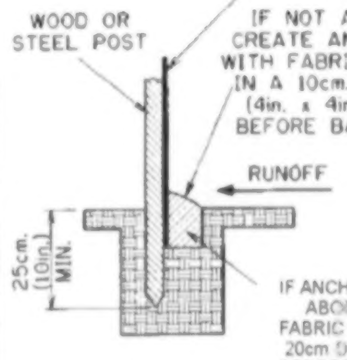
MAINTENANCE

THE FABRIC IS TO BE INSPECTED AND REPAIRS COMPLETED AFTER EVERY STORM EVENT. SEDIMENT DEPOSITS SHALL BE REMOVED ONCE COLLECTED MATERIAL REACHES A DEPTH OF ONE-HALF THE FENCE HEIGHT.


FILTER FABRIC MATERIAL
SPACING OF POST TO BE 2-3 METRES (6-10 FT.) APART
60cm (2 FT.)
BACKFILLED TRENCH

FOR ADDITIONAL STRUCTURAL STRENGTH, FABRIC MATERIAL CAN BE ATTACHED TO A 15cm. (6 in.) MESH WIRE SCREEN WHICH HAS BEEN FASTENED TO THE POSTS.

TO REDUCE THE POTENTIAL OF BLOWOUTS, ANCHORS CAN BE ATTACHED TO THE FABRIC MATERIAL BEFORE BACKFILLING THE TRENCH.

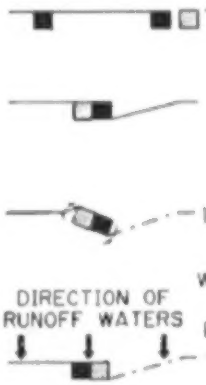

WOOD OR STEEL POST
RUNOFF
25cm. (10in.) MIN.

FILTER FABRIC MATERIAL SECURELY FASTENED TO THE POSTS OR (IF USED) THE WIRE MESH

IF NOT ANCHORED, CREATE AN 'L' SHAPE WITH FABRIC MATERIAL IN A 10cm. x 10cm. (4in. x 4in.) TRENCH BEFORE BACKFILLING

IF ANCHORED, INSERT ABOUT 20cm OF FABRIC MATERIAL IN 20cm DEEP TRENCH BEFORE BACKFILLING.

ATTACHING TWO SILT FENCES


DIRECTION OF RUNOFF WATERS

PLACE THE END POST OF THE SECOND FENCE INSIDE THE END POST OF THE FIRST FENCE

ROTATE BOTH POSTS AT LEAST 100 DEGREES IN A CLOCKWISE DIRECTION TO CREATE A TIGHT SEAL WITH THE FABRIC MATERIAL

DRIVE BOTH POSTS ABOUT 25cm. (10in.) INTO THE GROUND AND BURY FLAP

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SILT FENCE
INSTALLATION

Drawn LE
Scale N.T.S.
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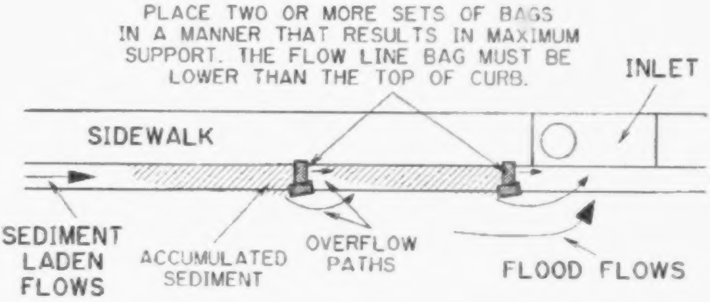
For City Engineer


PLACE TWO OR MORE SETS OF BAGS IN A MANNER THAT RESULTS IN MAXIMUM SUPPORT. THE FLOW LINE BAG MUST BE LOWER THAN THE TOP OF CURB.
INLET
SIDEWALK
SEDIMENT LADEN FLOWS
ACCUMULATED SEDIMENT
OVERFLOW PATHS
FLOOD FLOWS

NOTE: BAGS MUST BE PARTIALLY (ABOUT 2/3) FULL

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GRAVEL BAG
CURB FILTER

Sheet
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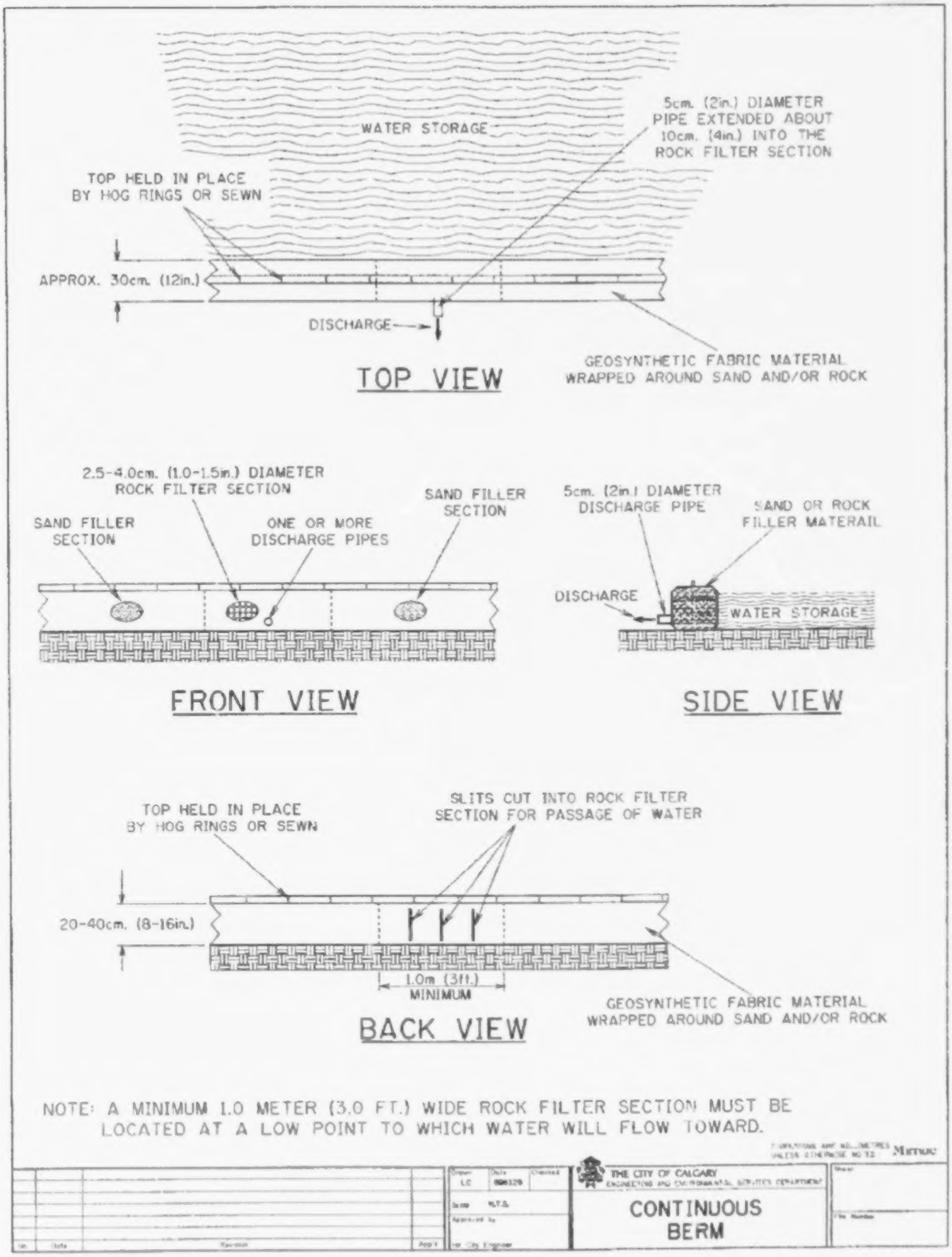
WATER STORAGE
5cm. (2in.) DIAMETER PIPE EXTENDED ABOUT 10cm. (4in.) INTO THE ROCK FILTER SECTION
TOP HELD IN PLACE BY HOG RINGS OR SEWN
APPROX. 30cm. (12in.)
DISCHARGE
GEOSYNTHETIC FABRIC MATERIAL WRAPPED AROUND SAND AND/OR ROCK
2.5-4.0cm. (1.0-1.5in.) DIAMETER ROCK FILTER SECTION
SAND FILLER SECTION
ONE OR MORE DISCHARGE PIPES
SAND FILLER SECTION
5cm. (2in.) DIAMETER DISCHARGE PIPE
SAND OR ROCK FILLER MATERAIL
DISCHARGE
WATER STORAGE
TOP HELD IN PLACE BY HOG RINGS OR SEWN
SLITS CUT INTO ROCK FILTER SECTION FOR PASSAGE OF WATER
20-40cm. (8-16in.)
1.0m (3ft.) MINIMUM
GEOSYNTHETIC FABRIC MATERIAL WRAPPED AROUND SAND AND/OR ROCK
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TOP VIEW

FRONT VIEW

SIDE VIEW

BACK VIEW

NOTE: A MINIMUM 1.0 METER (3.0 FT.) WIDE ROCK FILTER SECTION MUST BE LOCATED AT A LOW POINT TO WHICH WATER WILL FLOW TOWARD.

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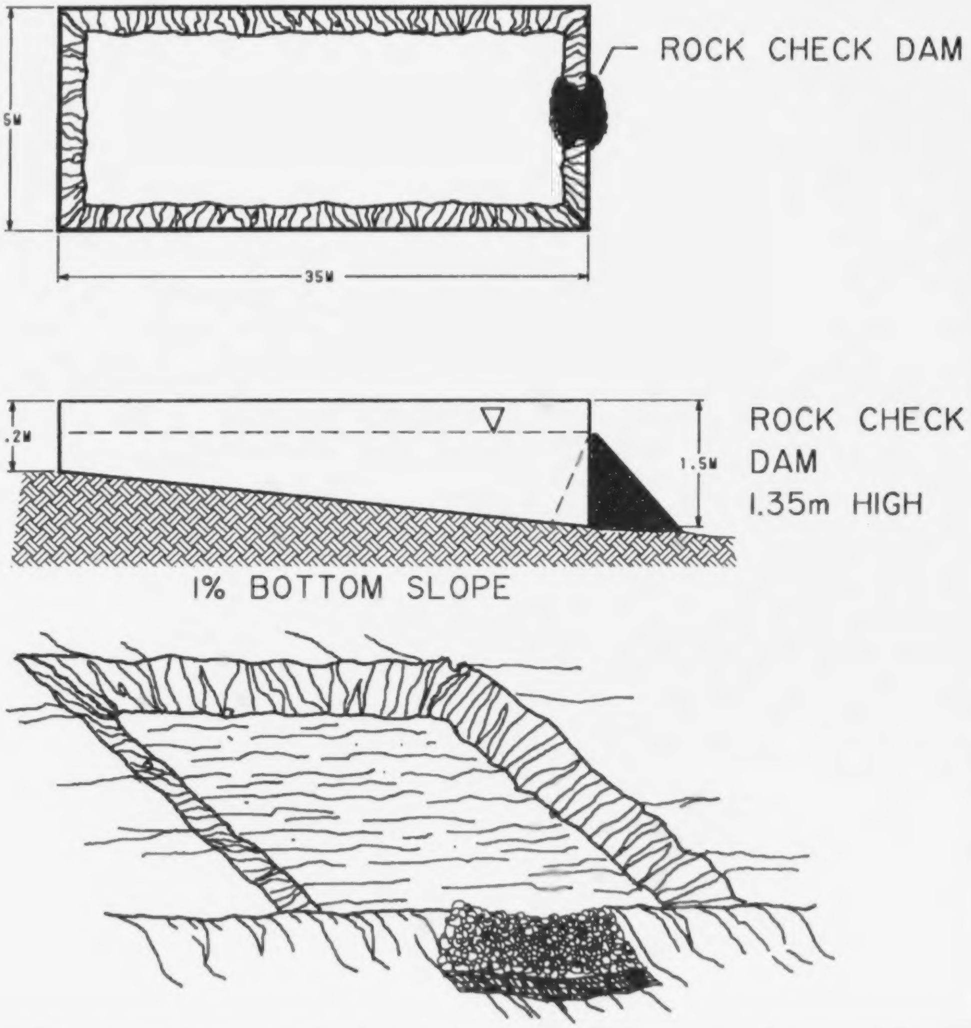
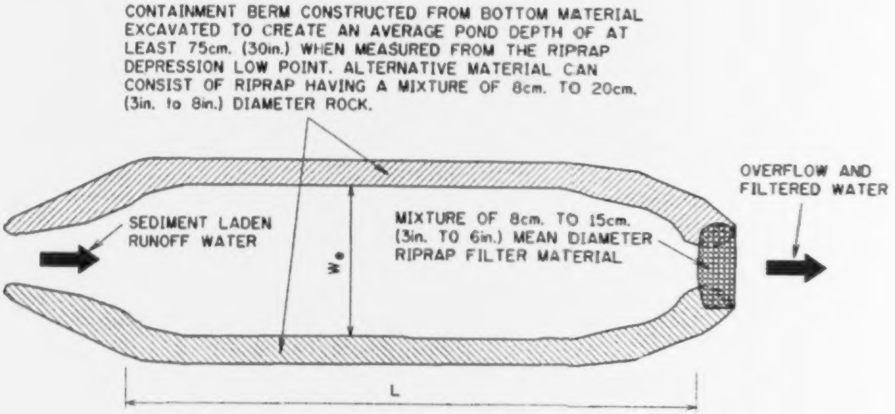
CONTINUOUS
BERM

SEDIMENT TRAP

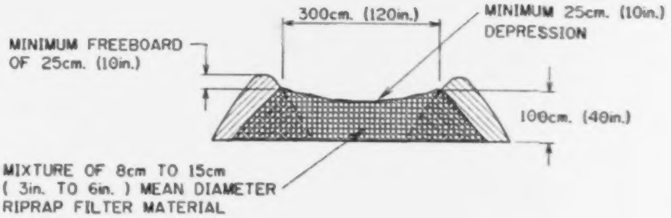
N.T.S.



ROCK CHECK DAM
15M
35M
1.2M
1.5M
ROCK CHECK DAM 1.35m HIGH
1% BOTTOM SLOPE


CONTAINMENT BERM CONSTRUCTED FROM BOTTOM MATERIAL EXCAVATED TO CREATE AN AVERAGE POND DEPTH OF AT LEAST 75cm. (30in.) WHEN MEASURED FROM THE RIPRAP DEPRESSION LOW POINT. ALTERNATIVE MATERIAL CAN CONSIST OF RIPRAP HAVING A MIXTURE OF 8cm. TO 20cm. (3in. to 8in.) DIAMETER ROCK.
OVERFLOW AND FILTERED WATER
SEDIMENT LADEN RUNOFF WATER
W_e
MIXTURE OF 8cm. TO 15cm. (3in. TO 6in.) MEAN DIAMETER RIPRAP FILTER MATERIAL
L

PLAN VIEW


300cm. (120in.)
MINIMUM 25cm. (10in.) DEPRESSION
MINIMUM FREEBOARD OF 25cm. (10in.)
100cm. (40in.)
MIXTURE OF 8cm TO 15cm (3in. TO 6in.) MEAN DIAMETER RIPRAP FILTER MATERIAL

OUTLET VIEW

DIMENSIONS ARE MILLIMETRES UNLESS OTHERWISE NOTED
METRIC

No.	Date	Revision	App'd

Drawn: LC
Date: 000329
Checked:
Scale: N.T.S.
Approved by
for City Engineer

THE CITY OF CALGARY
ENGINEERING AND ENVIRONMENTAL SERVICES DEPARTMENT

SINGLE CHAMBER SEDIMENT TRAP

Sheet:
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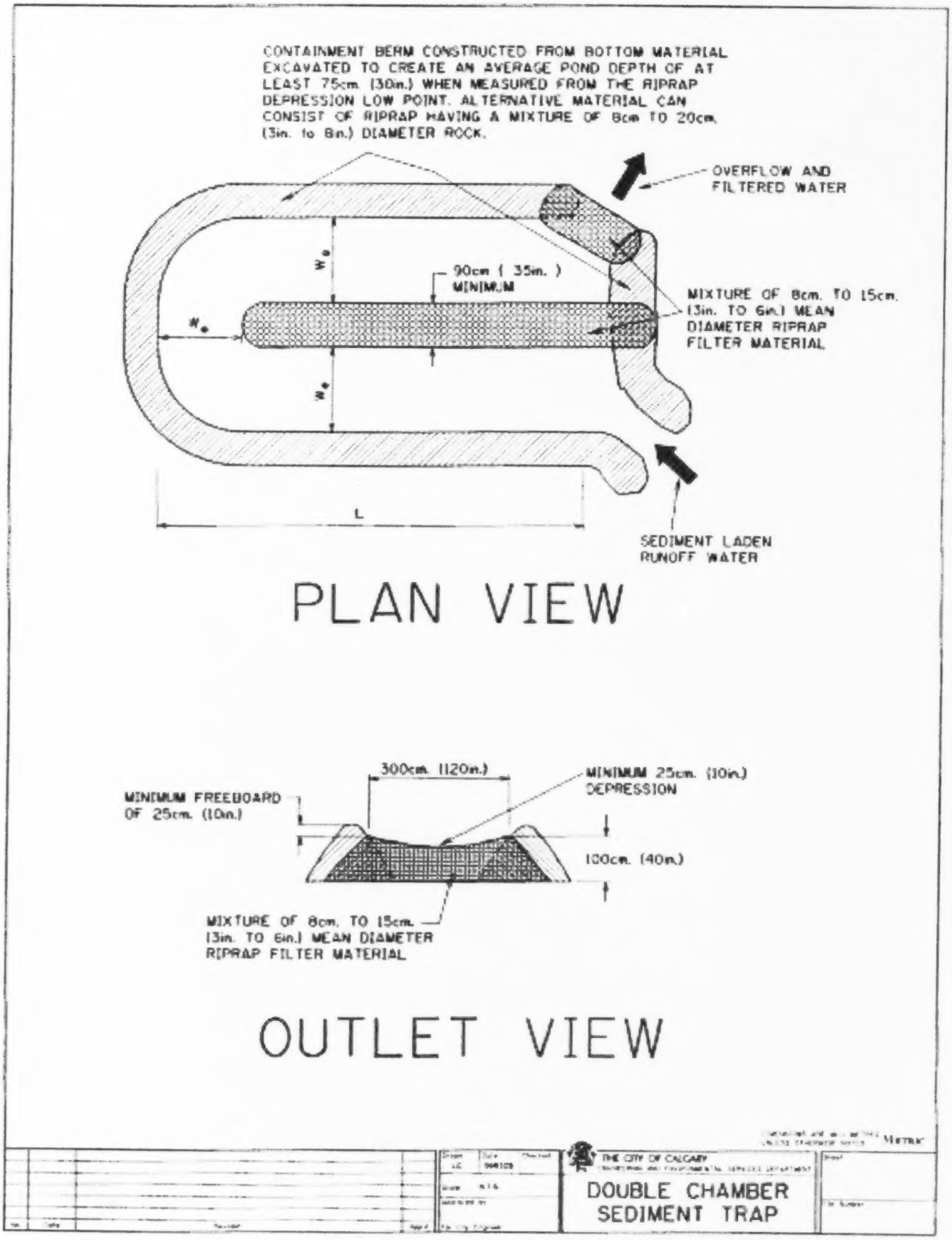
CONTAINMENT BERM CONSTRUCTED FROM BOTTOM MATERIAL EXCAVATED TO CREATE AN AVERAGE POND DEPTH OF AT LEAST 75cm. (30in.) WHEN MEASURED FROM THE RIPRAP DEPRESSION LOW POINT. ALTERNATIVE MATERIAL CAN CONSIST OF RIPRAP HAVING A MIXTURE OF 8cm TO 20cm. (3in. to 8in.) DIAMETER ROCK.
OVERFLOW AND FILTERED WATER
W
90cm (35in.) MINIMUM
W
MIXTURE OF 8cm. TO 15cm. (3in. TO 6in.) MEAN DIAMETER RIPRAP FILTER MATERIAL
W
L
SEDIMENT LADEN RUNOFF WATER
PLAN VIEW
300cm. (120in.)
MINIMUM 25cm. (10in.) DEPRESSION
MINIMUM FREEBOARD OF 25cm. (10in.)
100cm. (40in.)
MIXTURE OF 8cm. TO 15cm. (3in. TO 6in.) MEAN DIAMETER RIPRAP FILTER MATERIAL
OUTLET VIEW
Metric
THE CITY OF CALGARY
DOUBLE CHAMBER SEDIMENT TRAP

Glossary

Best Management Practice (BMP): Activities, practices, and maintenance procedures that prevent or reduce the release of pollutants to waters. The techniques lessen the environmental impacts of land used, and may involve structures, vegetation, or altering construction operations.

Berm: A constructed barrier of compacted earth, rock or gravel.

Channel: A feature that conveys surface water and is open to the air. Channels may be constructed or natural.

Check Dam: Small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.

Contour Line: An imaginary line on the surface of the earth connecting points of the same elevation. Contour lines provide a representation of the land slopes and topography.

Denuded Area: A portion of land surface on which the vegetation or other soil stabilization features have been removed, destroyed, or covered, and which may erode.

Design Storm: A rainfall event of specified size and return frequency (i.e. a storm that has a return period of 2 years), which is used to calculate the runoff volume and peak flow rate.

Ditch: A long narrow excavation dug in the earth for drainage.

Dormancy: The condition of a plant or seed in which life functions are virtually at a standstill.

Downcutting: Channel erosion characterized by erosion of the channel bottom, causing the channel to deepen and become entrenched. Also referred to incising.

Earth-disturbing Activity: Any grading, excavating, filling or other alteration of the earth's surface where natural or man-made ground cover is destroyed.

Erosion/Sedimentation Control: Any temporary or permanent measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment-laden water does not leave the site.

Exfiltration: The downward movement of runoff through the bottom of an infiltration trench, into the ground.

Fascine: A long bundle of sticks or wood bound together and used for such purposes as filling ditches and making revetments for river banks.

Fathom: A measure of depth of water equal to 6 feet.

Fertilizer Analysis: The percentage of fertilizer, expressed in terms of nitrogen, phosphoric acid, and potash. For example, a fertilizer with a 6-12-6 contains 6% nitrogen (N), 12% available phosphoric acid (P_2O_5), and 6% water-soluble potash (K_2O).

Filter Fabric: A woven or nonwoven, water permeable material generally made of synthetic products such as polypropylene used in erosion and sediment control applications to trap sediment or prevent clogging of aggregates by fine soil particles.

Forb: An herb other than grass.

Freeboard: The vertical distance between the design water surface elevation and the maximum possible elevation before overtopping.

Frequency of Storm: The anticipated period in years that will elapse, based on average probability of storms in the design region, before a storm of a given intensity and/or total volume will recur.

Gabion: A rectangular wire mesh cage filled with rock that may be used to prevent erosion, or as a retaining wall.

Geotextile: See Filter fabric.

Grading: Earth disturbing activities including excavation, cutting, filling, stockpiling, or any combination thereof.

Grassed Waterway: A natural or constructed waterway, usually broad and shallow, covered with erosion resistant grasses, used to conduct surface water from an area at a reduced flow rate.

Grubbing: Removing stumps, roots or brush.

Gully: A channel caused by the concentrated flow of surface and stormwater runoff over unprotected erodible land.

Impoundment: A natural or man-made containment for surface water.

Infiltration: The gradual downward flow of water from the surface through to groundwater.

Low Flow (Base Flow): The stream flow sustained between runoff events. Its primary source is groundwater.

Outlet: Point of water disposal from a stream, river, lake, tidewater, or artificial drain.

Permeability: The capacity for transmitting runoff through a material or into the soil. It is measured by the rate at which a fluid of standard viscosity can move through the material in a given interval of time, under a given hydraulic gradient.

Piping: Seepage or subsurface flow often causing removal of soil, eroding larger and larger pathways or "pipes".

Rill: A small intermittent watercourse with steep sides, usually only a few inches deep. Rills are often caused by an increase in surface water flow when soil is cleared of vegetation.

Riprap: Rock or stone placed over a bedding of geotextile or sand, used to armour slopes against flowing water or wave action.

Riser: A vertical pipe extending from the bottom of a BMP pond that is used to control the discharge rate.

Runoff: Water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, seeps, ponds, lakes as well as shallow ground water.

Sediment: Fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspend in, or deposited by water.

Sedimentation: The depositing or formation of sediment.

Settling Pond: Any pond used as a sediment basin or sediment trap.

Sheet Erosion: The relatively uniform removal of soil from an area without the development of conspicuous water channels.

Sheet Flow: Diffuse runoff flowing overland in a thin layer not concentrated and not in a defined channel.

Siltation: The process by which a river, lake or other body becomes clogged with sediment. Silt can clog gravel beds and affect aquatic fish habitat.

Soil Stabilization: Vegetative or structural soil cover controlling erosion that includes permanent and temporary seed, mulch, sod, pavement, etc.

Source Control BMP: A BMP that is intended to prevent pollutants from entering stormwater. Examples include erosion control practices and maintenance of facilities.

Stream: A system including permanent or seasonally flowing water, a defined channel, floodplain, and riparian ecosystem. Streams have no defined size range, but are generally considered smaller than rivers.

Stormwater Treatment: The removal of pollutants from urban runoff and improvements in water quality, accomplished largely by deposition and utilizing the benefits of natural processes.

Topography: General term to include characteristics of the ground surface such as plains, hills, mountains, degree of relief, steepness of slopes and other physiographic features.

Treatment BMP: A BMP that is intended to remove pollutants from stormwater. Examples include sediment traps and pond, and oil/grit separators.

Vegetation: All organic plant life growing on the surface of the earth.

Water Body: Surface waters including rivers, streams, lakes, and wetlands.